

Evaluation of Chemical Compatibilities of the OU 7-10 Glovebox Excavator Method Project

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June 2002



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ABSTRACT

This document presents an evaluation of the potential for incompatible chemical reactions in the waste inventory in Operable Unit 7-10 (Pit 9) of the Subsurface Disposal Area at the Radioactive Waste Management Complex of the Idaho National Engineering and Environmental Laboratory. In this assessment, the range of possible chemical combinations that could occur (i.e., binary combinations) during excavation, repackaging, and storage were considered. The potential adverse chemical reactions (e.g., generation of fire, explosion, heat, or fumes) that stem from combining chemicals also were considered.

All of the binary combinations of the chemicals known to be in the project area were examined. One conclusion of the evaluation is that no anticipated or postulated reactions could lead to explosion, rupturing of containers, fire, or hazardous fumes; therefore, the chemicals are not incompatible at ambient temperatures.

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TABLE

1.	Waste content in the Operable Unit 7-10 Stage I and II areas	7
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ACRONYMS

AMWTF	Advanced Mixed Waste Treatment Facility
CCA	chemical compatibility assessment
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
EDTA	ethylenediaminetetraacetic acid
EPA	U.S. Environmental Protection Agency
INEEL	Idaho National Engineering and Environmental Laboratory
ITRP	independent technical review panel
OU	operable unit
RFP	Rocky Flats Plant
ROD	Record of Decision
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area

Evaluation of Chemical Compatibilities of the OU 7-10 Glovebox Excavator Method Project

1. INTRODUCTION

1.1 Purpose

This document presents an evaluation of the potential for incompatible chemical reactions in the waste inventory of Operable Unit (OU) 7-10, which is located within the Subsurface Disposal Area (SDA) of the Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering and Environmental Laboratory (INEEL). This evaluation considered the range of possible chemical combinations (i.e., binary combinations) that could occur during excavation, repackaging, and storage. The potential adverse chemical reactions (e.g., generation of fire, explosion, heat, or fumes) that stem from combining chemicals at ambient temperatures also was considered. This evaluation will support the OU 7-10 Glovebox Excavator Method Project design, characterization, and operational decision-making process by determining whether any chemical combinations may potentially lead to adverse chemical reactions at ambient temperatures and affect project compliance and safety. A map showing the location of the RWMC at the INEEL is presented in Figure 1 followed by a map of the SDA showing the location of OU 7-10 (Pit 9), provided in Figure 2.

1.2 Background and Scope

The OU 7-10 Glovebox Excavator Method Project was developed by the U.S. Department of Energy Idaho Operations Office (DOE-ID) in consultation with the U.S. Environmental Protection Agency (EPA), Region 10, and the Idaho Department of Environmental Quality. The project is Stage II of the OU 7-10 interim action as defined in the *Record of Decision: Declaration of Pit 9 at the Radioactive Waste Management Complex Subsurface Disposal Area at the Idaho National Engineering Laboratory, Idaho Falls, Idaho* (DOE-ID 1993) and the *Explanation of Significant Differences for the Pit 9 Interim Action Record of Decision at the Radioactive Waste Management Complex at the Idaho National Engineering and Environmental Laboratory* (DOE-ID 1998).

Stage I involved installation of probe casings for collecting nonintrusive characterization information. Stage II includes limited retrieval and excavation in selected areas of OU 7-10. Through retrieving waste in OU 7-10, Stages I and II are designed to provide characterization and other information needed for assessment of the radioactive and hazardous waste disposed of in the SDA.

The OU 7-10 Glovebox Excavator Method Project supports accomplishing the objectives of the OU 7-10 (Pit 9) Record of Decision (ROD) (DOE-ID 1993) and the 1998 Explanation of Significant Differences (DOE-ID 1998). In June 2000, the draft U.S. Department of Energy Idaho Operations Office (DOE-ID) 90% Remedial Design and Remedial Action Work Plan^a was submitted for agency review. Schedule considerations associated with that document have led to a modified approach for Stage II as described in *Waste Area Group 7 Analysis of OU 7-10 Stage II Modifications* (INEEL 2001) and the *OU 7-10 Glovebox Excavator Method Project Conceptual Design Report for Critical Decision 1* (INEEL 2002).

a. DOE-ID, 2000, "Draft Operable Unit 7-10 (OU 7-10) Staged Interim Action Project, Stage II, RD/RA Work Plan Primary Deliverable Submittal," Binder I-A, "Remedial Design/Remedial Action Work Plan for Stage II of the Operable Unit 7-10 (OU 7-10) Staged Interim Action Project," DOE/ID-10767, U.S. Department of Energy Idaho Operations Office, Idaho Falls, Idaho.

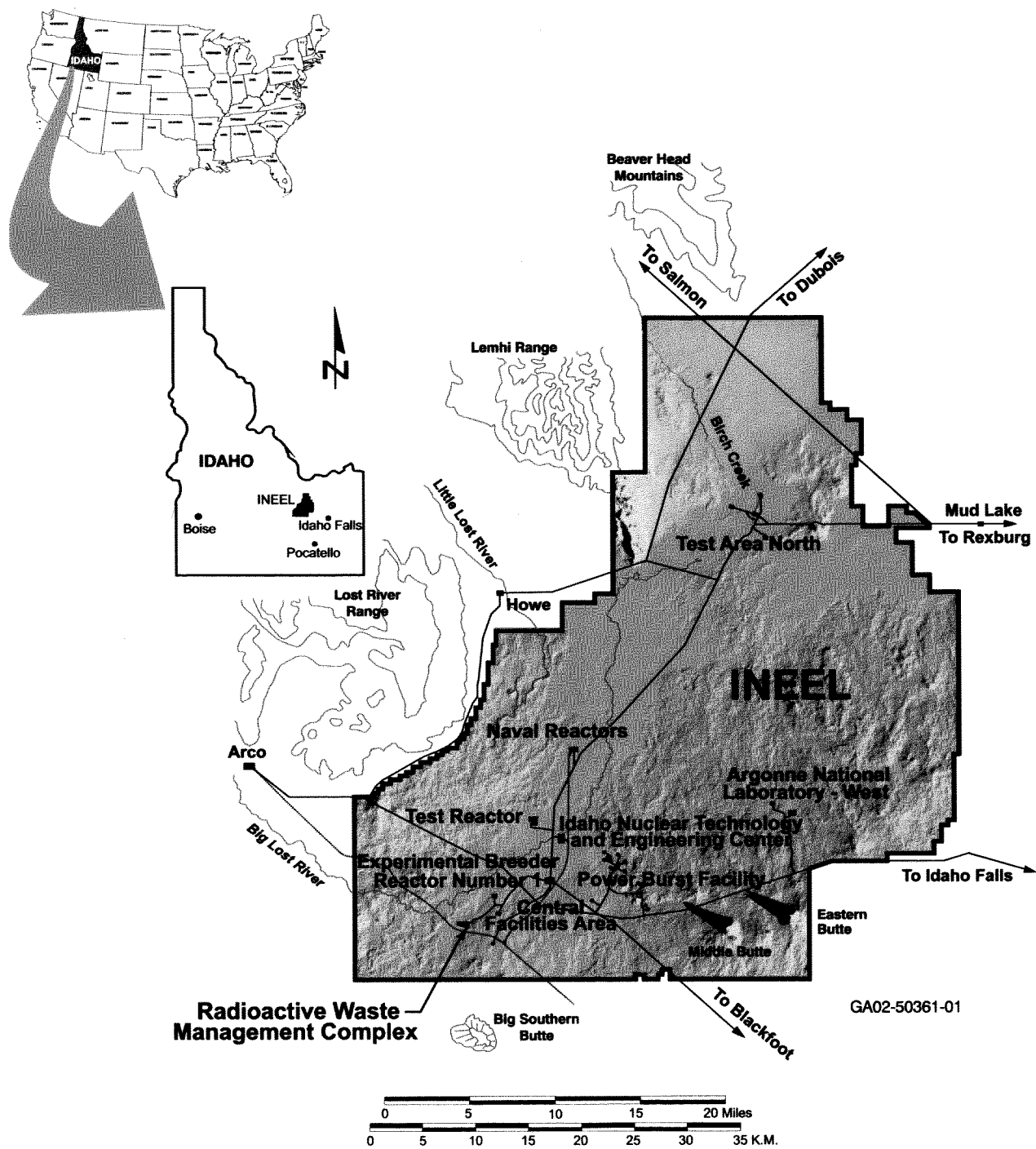


Figure 1. Location of the Radioactive Waste Management Complex at the Idaho National Engineering and Environmental Laboratory.

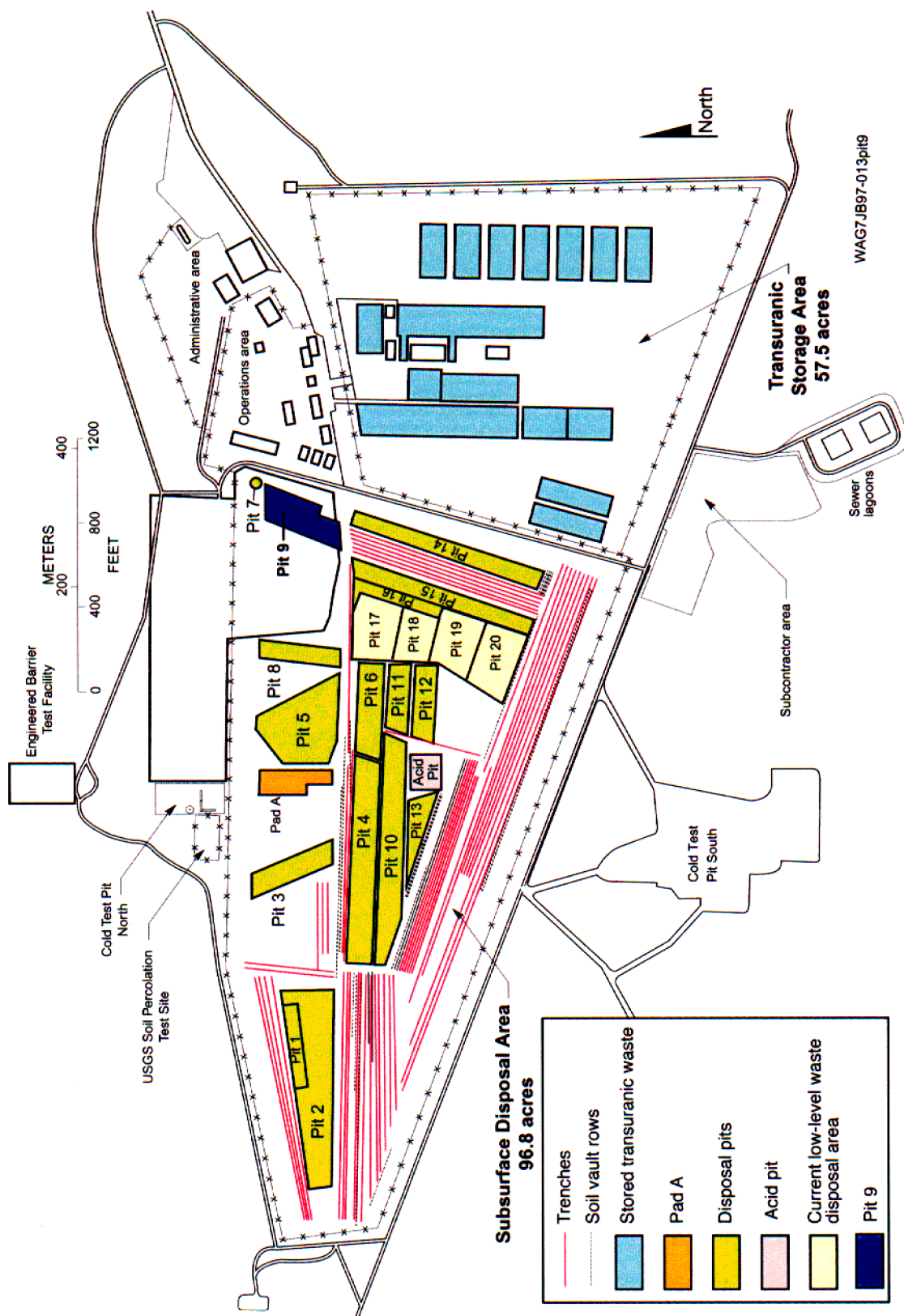


Figure 2. Map of the Subsurface Disposal Area showing the location of Operable Unit 7-10 (Pit 9).

Retrieval activities planned for the project involve excavating a limited area in the southern portion of OU 7-10. The location of the OU 7-10 Glovebox Excavator Method Project relative to the SDA is illustrated in Figure 3, which also provides a graphical representation of the glovebox excavator method. The glovebox excavator method relies on a standard swing-boom commercial excavator that is operated manually from the excavator cab. The excavator arm is located inside a confinement structure positioned over the excavation area. The rest of the excavator remains outside the confinement structure.

The excavator arm excavates a semicircular swath of overburden and then the waste. The retrieved material in the excavator bucket is placed in a transfer cart that transports soil, waste, and intact drums into three gloveboxes that are attached to the confinement structure. The waste is inspected, categorized, and sampled inside the gloveboxes. Each of the gloveboxes is equipped with three drum bagout stations for packaging the retrieved materials. The drums are then transferred to the Advanced Mixed Waste Treatment Facility (AMWTF) for further processing (INEEL 2001).

In this evaluation, the range of possible chemical combinations that could occur during excavation and retrieval (i.e., binary combinations) was considered, as were potential adverse chemical reactions (e.g., generation of fire, explosion, heat, or fumes) that could stem from combining the chemicals. As discussed in Section 2, a significant amount of work has been performed already to evaluate chemical compatibilities in the OU 7-10 contaminant inventory. Those evaluations have been documented in the *Chemical Compatibility Assessment for Operable Unit 7-10 Stage I and II Waste Generation Activities* (INEEL 2000). This current work builds on previous efforts and presents an expanded technical evaluation of chemical combinations of potential concern. The organizational structure of this document is listed below.

- **Remainder of Section 1** presents a summary of the documentation used to estimate the contaminant inventory of OU 7-10
- **Section 2** presents background information about previous assessments of chemical compatibilities
- **Section 3** provides additional technical literature that presents an expanded evaluation of chemical compatibilities
- **Section 4** presents the summary and conclusions based on the evaluation provided in Section 3
- **Section 5** presents recommendations based on the evaluation provided in Section 3
- **Section 6** presents a list of the references cited throughout this document
- **Appendix A** includes waste description and packaging information important to the chemical compatibility evaluation in Section 3
- **Appendix B** contains the range of all potential binary combinations of chemicals in OU 7-10 determined in the Chemical Compatibility Assessment (CCA) for OU 7-10 (INEEL 2000).

1.3 Stage II Waste Inventory

Operable Unit 7-10 was used for disposal of radioactive and hazardous chemical waste from November 8, 1967, to June 9, 1969. Inventories of the waste in OU 7-10 and the SDA pits and trenches have been generated using existing and available historical records. The records are incomplete for

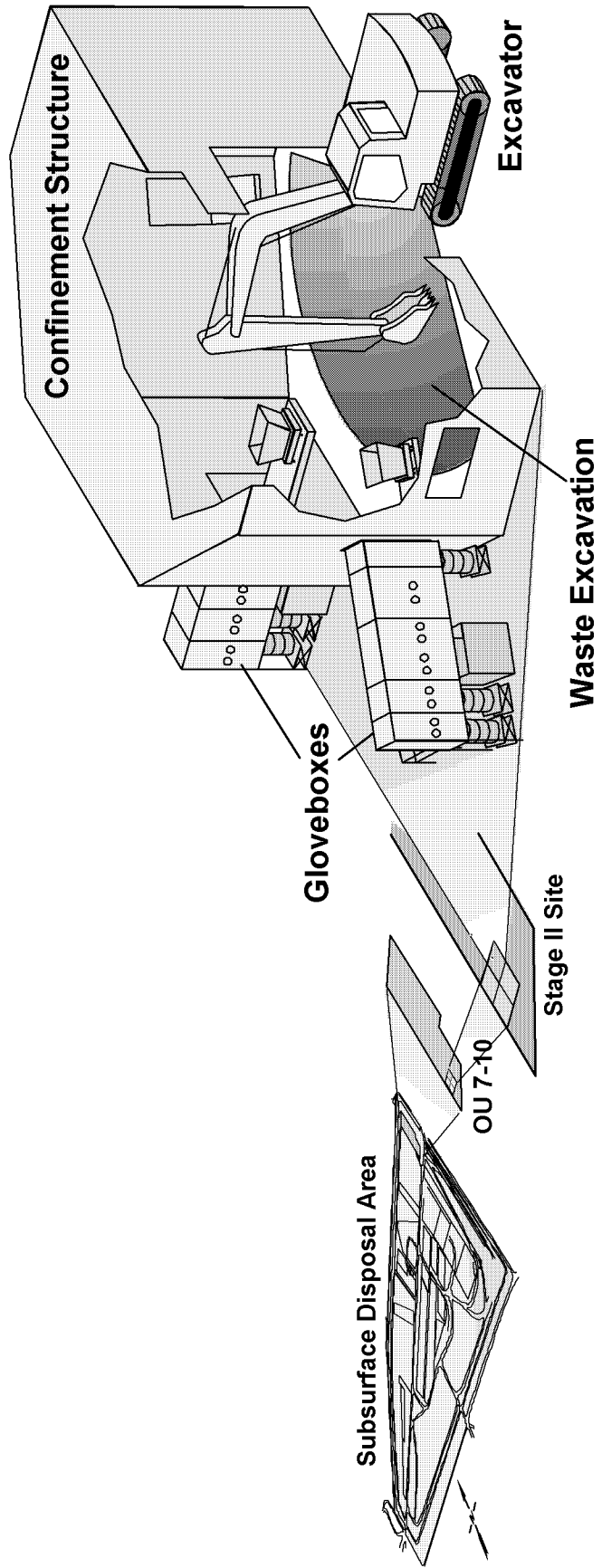


Figure 3. Location of the OU 7-10 Glovebox Excavator Method Project relative to the Subsurface Disposal Area and graphical representation of the glovebox excavator method.

various items including exact locations of drums inside the pit, the extent of contaminant migration, specific isotopic information and chemical form, and the valence state of the contaminants.

The transuranic waste disposed of in OU 7-10 was primarily produced at the Rocky Flats Plant (RFP).^b Approximately 3,115 m³ (4,074 yd³) of the estimated 4,250 m³ (5,559 yd³) of waste in OU 7-10 was generated at RFP. Other materials in OU 7-10 include low-level waste from generators located at the INEEL. The waste in OU 7-10 was produced from RFP weapons production operations and INEEL nuclear reactor testing activities and includes a variety of radionuclides, organic compounds, and inorganic compounds. An inventory of these materials is detailed in the OU 7-10 ROD. In addition to waste, the pit contains an estimated 7,079 m³ (9,259 yd³) of overburden soil and approximately 9,911 m³ (12,963 yd³) of interstitial and underburden soil between and below the buried waste.

While OU 7-10 was operational, drums generally were dumped into the pit by truck or bulldozer. Large items were placed in the pit by crane. Soil cover was applied over the waste after weekly or daily operations, depending on the required procedures at the time of disposal. After the waste was placed in the pit, the pit was backfilled with another layer of soil. An additional soil layer was added to the pit a number of years after the original closure, though details about the year or depth of soil added are not available.

The OU 7-10 ROD inventory was compiled from the two documents listed below:

- *Nonradionuclide Inventory in Pit 9 at the RWMC* (Liekhus 1992), which was converted from an earlier report, *Nonradionuclide Inventory in Pit 9 at the RWMC* (Liekhus 1991)
- *Methodology for Determination of a Radiological Inventory for Pit 9 and Corresponding Results* (King 1991).

From the time the OU 7-10 ROD was written, a number of refinements to the inventory estimates have been made based on various new information sources. The current OU 7-10 inventory document is the *Pit 9 Estimated Inventory of Radiological and Nonradiological Constituents* (Einerson and Thomas 1999), which documents the estimated inventory for the entire disposal pit from all generators but does not focus on the Stage I and II areas in the southern portion of OU 7-10. Inventory information pertinent to the Stage I and II areas is summarized in Table 1.

The OU 7-10 Stage I and II areas contain waste streams from the RFP. Waste from various INEEL facilities was disposed of elsewhere in OU 7-10.^c The waste in the Stage I and II areas of OU 7-10 was shipped from the RFP in 55-gal drums (see footnote c). The drum quantity estimates shown in Table 1 are for the entire 12.2 x 12.2-m (40 x 40-ft) Stage I and II areas (see footnote c). The actual excavation in Stage II will be limited to a portion of the overall area; therefore, only a portion of the total number of drums will be encountered during Stage II retrieval operations. Appendix A includes waste description and packaging information for the Series 741 to 745 sludge (Clements 1982) that is important to the chemical compatibility evaluation presented in Section 3.

b. The Rocky Flats Plant is located 26 km (16 mi) northwest of Denver, Colorado. In the mid-1990s it was renamed the Rocky Flats Environmental Technology Site. In the late 1990s it was again renamed to its present name, the Rocky Flats Plant Closure Project.

c. Roderick W. Thomas, 1999, Interdepartmental Memorandum to David E. Wilkins, April 16, 1999, "Waste Contents Associated with OU 7-10 Stages I/II Activities in Pit 9," RWT-01-99, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

Table 1. Waste content in the Operable Unit 7-10 Stage I and II areas.

Waste Stream	Summary Characteristics	Description of Packaging	Estimated Quantity (drums)
Series 741 sludge—first stage sludge	Salt precipitate containing plutonium and americium oxides, depleted uranium, metal oxides, and organic constituents.	18.1 to 22.7 kg (40 to 50 lb) of Portland cement added to the top and bottom of the drum to absorb any free liquids. Two plastic bags.	3
Series 742 sludge—second stage sludge	Salt precipitate containing plutonium and americium oxides, metal oxides, and organic constituents.	18.1 to 22.7 kg (40 to 50 lb) of Portland cement added in layers to absorb any free liquids. Two plastic bags.	27
Series 743 sludge—organic setups	Organic liquid waste solidified using calcium silicate (paste or grease-like).	113.6 L (30 gal) of organic waste mixed with 45.4 kg (100 lb) calcium silicate. Small quantities (4.5 to 9.1 kg [10 to 20 lb]) of Oil-Dri added to top and bottom, if necessary. Two plastic bags.	379
Series 744 sludge—special setups	Complex chemicals (liquids) including ethylenediaminetetraacetic acid (EDTA), organic acids, and alcohols solidified with cement.	86.2 kg (190 lb) of Portland cement and 22.7 kg (50 lb) of magnesia cement in drum followed by the addition of 99.9 L (26.4 gal) of liquid waste. Additional cement on top and bottom. Two plastic bags.	2
Series 745 sludge—evaporator salts	Salt residue from evaporated liquids from solar ponds containing 60% sodium nitrate, 30% potassium nitrate, and 10% miscellaneous.	Salt residue packaged in plastic bag and drum. Cement added to damp or wet salt when necessary.	42
Noncombustible waste	Various miscellaneous waste such as gloveboxes, lathes, ducting, piping, angle iron, electronic instrumentation, pumps, motors, power and hand tools, chairs, and desks.	Packaging varies by process line generating the waste. Waste may have been wrapped in plastic or placed directly into the waste container.	28
Combustible waste	Dry combustible materials such as paper, rags, plastics, surgeons' gloves, cloth coveralls and booties, cardboard, wood, wood filter frames, and polyethylene bottles.	Packaging varies by process line generating the waste. Plastic bags were used in some instances; however, in other instances waste was placed directly into waste container.	260
Graphite	Graphite mold pieces after excess plutonium removal. Molds are broken into large pieces before packaging.	Drums lined with polyethylene bags and most likely a cardboard liner.	22
Empty 55-gal drums	Empty drums that originally held lathe coolant at the Rocky Flats Plant. Some drums may contain residues.	Single drum placed in cardboard carton.	544

The summary characteristics column in Table 1 shows that the RFP waste forms contain various radiological and nonradiological contaminants. The material shipped to OU 7-10 from RFP included weapons-grade plutonium, Am-241, and uranium isotopes. Weapons-grade plutonium (i.e., Pu-52) contains Pu-238, Pu-239, Pu-240, Pu-241, and Pu-242. In addition, some Am-241 and Np-237 are daughters resulting from the radioactive decay of Pu-241. Also included in the waste shipments was additional Am-241. This Am-241 did not result from the decay of OU 7-10 inventory but was removed from Pu-52 during processing at RFP. This additional Am-241 is a significant contributor to the total radioactivity located in OU 7-10. Uranium isotopes shipped to the RWMC included U-235 and U-238. A number of radionuclides including Co-60, Cs-137, Sr-90, Y-90, and Ba-137, which originated primarily from INEEL waste generators, are not expected to be found in the Stage II area.

The primary organic chemicals known to be in OU 7-10 include carbon tetrachloride, trichloroethene, 1,1,1-trichloroethane, tetrachloroethene, lubricating oils, Freon 113, alcohols, organic acids, and Versenes (specifically ethylenediaminetetraacetic acid [EDTA]). Examples of inorganic chemicals known to be in the waste include hydrated iron, zirconium, beryllium, lead, sodium nitrate, potassium nitrate, cadmium, dichromates, potassium phosphate, potassium sulfate, silver, asbestos, and calcium silicate. Calcium metal also may be expected because it was used for reduction of plutonium fluoride. "Prior to 1974, nitric acid was not rinsed from combustibles prior to removal from the glovebox and a risk of spontaneous combustion has been identified" (LMITCO 1996). A few chemicals causing potential significant safety or regulatory concerns were reported as having been disposed of somewhere in the SDA, though it is not possible to verify that the chemicals were buried in OU 7-10. These chemicals include sodium and potassium cyanide, lithium oxide, mercury, nitrobenzene, picric acid, and polychlorinated biphenyls. Regardless of the uncertainties, these chemicals are included in the overall chemical compatibility evaluations for OU 7-10 to ensure a bounding evaluation.

1.4 Regulatory References

Compatibility issues are addressed in several Resource Conservation and Recovery Act sections of the "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities" (40 CFR 264). Those sections include but are not limited to the following:

- 40 CFR 264.17, "General requirements for ignitable, reactive, or incompatible wastes," which states the following:
 - (a) The owner or operator must take precautions to prevent accidental ignition or reaction of ignitable or reactive waste. This waste must be separated^d and protected from sources of ignition or reaction including, but not limited to: (1) open flames, (2) smoking, (3) cutting and welding, (4) hot surfaces, (5) frictional heat, (6) sparks (static, electrical, or mechanical), (7) spontaneous ignition (e.g., from heat-producing chemical reactions), and (8) radiant heat. While ignitable or reactive waste is being handled, the owner or operator must confine smoking and open flame to specially designated locations. No Smoking signs must be conspicuously placed wherever there is a hazard from ignitable or reactive waste.
 - (b) Where specifically required by other sections of this part, the owner or operator of a facility that treats, stores or disposes of ignitable or reactive waste,

d. Separation is typically met through distance or barriers.

or mixes incompatible waste or incompatible waste and other materials, must take precautions to prevent reactions which:

- (1) Generate extreme heat or pressure, fire or explosions, or violent reactions;
- (2) Produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to threaten human health or the environment;
- (3) Produce uncontrolled flammable fumes or gases in sufficient quantities to pose a risk of fire or explosions;
- (4) Damage the structural integrity of the device or facility;
- (5) Through other like means threaten human health or the environment.

(c) When required to comply with paragraph (a) or (b) of this section, the owner or operator must document that compliance. This documentation may be based on references to published scientific or engineering literature, data from trial tests (e.g., bench scale or pilot scale tests), waste analyses (as specified in 40 CFR 264.13), or the results of the treatment of similar waste by similar treatment processes and under similar operating conditions.

- 40 CFR 264.31, "Design and operation of facility," which states:

Facilities must be designed, constructed, maintained, and operated to minimize the possibility of fire, explosion, or any unplanned sudden or nonsudden release of hazardous waste or hazardous waste constituents to air, soil, or surface water which could threaten human health or the environment."

- 40 CFR 264.35, "Required aisle space," which states:

The owner or operator must maintain aisle space to allow the unobstructed movement of personnel, fire protection equipment, spill control equipment, and decontamination equipment to any area of facility operation in an emergency, unless it can be demonstrated to the Regional Administrator^e that aisle space is not needed for any of these purposes.

- 40 CFR 264 Subpart I, "Use and Management of Containers" (see 40 CFR 264.170 through 179), which includes the following requirements specific to compatibility:

- 40 CFR 264.172, "Compatibility of waste with containers," states "The owner or operator must use a container made of or lined with materials which will not react with, and are otherwise compatible with, the hazardous waste to be stored, so that the ability of the container to contain the waste is not impaired."

e. Regional administrator of the U.S. Environmental Protection Agency.

- 40 CFR 264.176, “Special requirements for ignitable or reactive waste,” states “Containers holding ignitable or reactive waste must be located at least 15 m (50 ft) from the facilities property line.”
- 40 CFR 264.177, “Special requirements for incompatible wastes,” which states:
 - (1) Incompatible wastes, or incompatible wastes and materials (see Appendix V for examples) must not be placed in the same container, unless 40 CFR 264.17(b) is complied with, (2) hazardous waste must not be placed in an unwashed container that previously held an incompatible waste or material, (3) a storage container holding a hazardous waste that is incompatible with any waste or other materials stored nearby in other containers, piles, open tanks, or surface impoundments must be separated from the other materials or protected from them by means of a dike, berm, wall, or other device.
- CFR 264.177(c) states “The purpose of this section is to provide guidance in preventing fires, explosions, gaseous emission, leaching, or other discharge of hazardous waste or hazardous waste constituents which could result from the mixing of incompatible wastes or materials if containers break or leak.”

Note that the requirements listed above from “Use and Management of Containers” (40 CFR 264 Subpart I) are identified as applicable or relevant and appropriate requirements in the OU 7-10 ROD.

Additional regulatory requirements that aid in addressing compatibility issues and safe management of waste include the following:

- 40 CFR 264.13(a)(1),(2), “General waste analysis”
- 40 CFR 264.15, “General inspection requirements”
- 40 CFR 264.16, “Personal training.”

While not all requirements presented above are identified as applicable or relevant and appropriate requirements for OU 7-10, the substantive provisions of the requirements will be met. The INEEL management control procedures require proper inspections and personnel training as well. The waste analysis required for the project will be agreed on with the regulatory agencies following project data quality objectives and sampling and analysis plans.

Other important sources of requirements relating to protection of workers and the public include the “National Oil and Hazardous Substances Pollution Contingency Plan (NCP)” (40 CFR 300) and a number of U.S. Department of Energy (DOE) orders. The National Contingency Plan (40 CFR 300) requires “Comprehensive Environmental Response, Compensation and Liability Act” (42 USC § 9601 et seq.) remedies to be protective of human health and the environment for both residual and short-term or operational risk factors. Hazardous chemical risks during operations are appropriately assessed as part of a remedy’s short-term effectiveness. Short-term risks may be further evaluated during remedial design and remedial action activities to ensure protective remedy implementation.

Determining whether waste contains incompatible materials also is required before sending waste to receiving facilities. As discussed previously, the project waste streams are planned for transfer to the AMWTF for processing. The AMWTF waste acceptance criteria includes restricting waste that contains incompatible materials.

2. SUMMARY OF EXISTING TECHNICAL DOCUMENTATION AND EVALUATION PROCESS

This section provides the technical documentation on which the refined chemical compatibility evaluation presented in Section 3 is based. As discussed in Section 1, the CCA (INEEL 2000) was prepared to assess the chemical compatibility considerations of the OU 7-10 contaminant inventory. This work builds on the previous effort in that this presents an expanded technical evaluation of chemical combinations of potential concern as identified in the CCA and as further explained below.

The CCA essentially followed the methodology for assessing chemical compatibility as presented in the EPA document *A Method for Determining the Compatibility of Hazardous Wastes* (EPA 1980). Consistent with EPA guidance, the CCA documented several tables presenting the range of all potential binary combinations of chemicals in OU 7-10 and conclusions about their compatibility. The range of all potential binary combinations of chemicals in OU 7-10 was based on the OU 7-10 contaminant inventories discussed in Section 1.3 (Einerson and Thomas 1999). The tables taken from Appendix B of the CCA are presented in Appendix B of this document. Table B-1 is an initial screening evaluation that assumes the following:

- The chemical constituents are in their pure form and reactions occur only between two chemical constituents at a time. In addition, sufficient chemical constituent is present for a reasonable, noticeable reaction to be evaluated.
- Metals, to be reactive, are in either a powdered form or particulate size (configuration) to provide sufficient surface area to initiate a chemical reaction.
- Chemical constituents were evaluated for reactivity and compatibility assuming standard temperature and pressure.

Table B-2 (see Appendix B) then limits the next evaluation step to those chemical combinations not screened out in Table B-1 (see Appendix B). Inventory information (e.g., concentration and waste form assumptions) that affects the potential for incompatible chemical reaction is considered in Table B-2. The evaluation process documented in Table B-2 identifies several groupings of chemicals with a potential for adverse chemical reactions if combined or mixed.

The evaluation documented in Section 3 was intended to expand the evaluation process that resulted in Table B-2. To that end, a refined evaluation of chemical properties, waste properties, and existing technical and testing data are used to determine whether the chemical compatibility groupings documented in Table B-2 present a reasonable potential for an adverse chemical reaction if combined in a remedial scenario. The refined evaluation purposely is limited to those binary chemical combinations documented in Table B-2 because the CCA was reviewed previously and developed with regulatory agency consensus. Therefore, reassessment of the full range of chemicals in the OU 7-10 contaminant inventory is unnecessary.

In addition to further evaluation of inventory documentation, two reports are cited to support the expanded chemical compatibility evaluation presented Section 3:

- *Independent Technical Review of Proposed Drilling Activities for Operable Unit 7-10 Staged Interim Action* (DOE 1999)
- *Nitrate Explosives Tests to Support the Operable Unit 7-13/14 In Situ Vittrification Project* (Dick 2001).

The Panel Report, Independent Technical Review of Proposed Drilling Activities for Operable Unit 7-10 Staged Interim Action (ITRP 1999) presents the results of an independent review of the OU 7-10 staged interim action by an independent technical review panel (ITRP). As part of the review, a safety assessment was performed to document potential explosions or fires in the pit that could occur during drilling and result in aboveground radiological releases.

This evaluation relies extensively on the Nitrate Explosives Tests report (Dick 2001) that documents tests conducted to support the OU 7-13/14 In Situ Vitrification Treatability Studies Project. The explosives tests were conducted to determine the reactivity of nitrate salts with oil, charcoal, graphite, and cellulose materials under conditions where in situ vitrification technology could be applied to waste buried in the SDA. Further information relative to incompatibility at ambient temperature was obtained by observing the mixtures before heating and by evaluating plots of time versus temperature during heating. The cited tests were conducted at elevated temperatures and thus are bounding conditions for what could occur at ambient temperatures. In general, the rate of a reaction at least doubles with each 10°C (18°F) rise in temperature. As all reactions occurred at temperatures of at least 200°C (392°F), the conclusions about reactivity at ambient temperature are valid. Observations of post-mixing behavior at ambient conditions while being transported to the test site have been added where relevant in Section 3. It is conceded that the impossibility of unexpected, unknown reactions has not been proven; however, no plausible, incompatible reactions have been identified.

3. REFINED CHEMICAL COMPATIBILITY EVALUATION

A refined chemical compatibility evaluation completed in 2002 of contaminants in the OU-7-10 inventory is presented in this section. Key definitions are provided below and in subsequent subsections. In addition, the binary chemical combinations assessed in the evaluation are provided. The refined evaluation is limited to those binary chemical combinations documented in Table B-2 (Appendix B) as having a potential for adverse chemical reactions. The approach outlined in the following subsections presents the binary chemical combinations of potential concern, as documented in Table B-2, and then further documents the assessment of the previous chemical combinations of potential concern.

A compatibility study including ternary combinations was considered and then rejected because, as stated in *A Method for Determining the Compatibility of Hazardous Wastes* (EPA 1980), it would be unwieldy. Furthermore, the mixtures considered in this analysis would involve solid-state reactions at ambient temperatures and pressures. The formation of a three-membered transition state in solids would be infrequent at best; therefore, reactions requiring three reactants to come together in a reactive intermediate would not be rapid. The possibility of sequential reactions involving three reactants also was considered and similarly evaluated. However, if a metal fire were to significantly heat the reactants, then a different outcome would be possible. Molten nitrates could come into intimate contact with fuels and react rapidly to produce a fire or deflagration.

Key definitions are provided below to enhance understanding of the chemical compatibility evaluation. The first three definitions were derived from DOE Manual 440.1-1, "DOE Explosives Safety Manual."

- **Explosive:** Any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, shock, or other suitable initiation stimulus, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate. The DOE explosives may be dyed various colors, except pink, which is reserved for mock explosives.
- **Deflagration:** A rapid chemical reaction in which the output of heat is sufficient to enable the reaction to proceed and be accelerated without input of heat from another source. Deflagration is a surface phenomenon with the reaction products flowing away from the unreacted material along the surface at subsonic velocity. The effect of a true deflagration under confinement is an explosion. Confinement of the reaction increases pressure, rate of reaction, and temperature, and may cause transition into a detonation.
- **Detonation:** A violent chemical reaction within a chemical compound or mechanical mixture involving heat and pressure. A detonation is a reaction that proceeds through the reacted material toward the unreacted material at a supersonic velocity. The result of the chemical reaction is exertion of extremely high pressure on the surrounding medium, forming a propagating shock wave that is originally of supersonic velocity. When the material is located on or near the surface of the ground, a detonation is normally characterized by a crater.

The energetic events (i.e., explosions) experienced in the nitrate explosives test series (Dick 2001) clearly represent deflagrations and not detonations. The drums were deformed, the lids blown off, and the sound heard, but nothing shattered. The reactions were explosions but not of the type that shatters rocks and concrete or fragments steel. In only one case (Dick 2001, Test 24), was a significant hole blown in the side of a drum; that event was judged a deflagration. However, it should be noted that deflagrations could be as damaging as detonations and can heave large objects or amounts of material.

Incompatible is defined by 40 CFR 260.10. The verbatim definition is provided below.

Incompatible waste: means a hazardous waste which is unsuitable for:

- (1) Placement in a particular device or facility because it may cause corrosion or decay of containment materials (e.g., container inner liners or tanks walls); or
- (2) Commingling with another waste or material under uncontrolled conditions because the commingling might produce heat or pressure, fire or explosion, violent reaction, toxic dusts, mists, fumes, or gases, or flammable fumes or gases.

Some of the examples used in the above definition are not qualified as to the extent of the event or consequence. For example, the definition from 40 CFR 260.10 would apply to reactions associated with heat generation of any degree or the generation of toxic gases at any concentration. Insufficient test data exist to preclude all possibility of reactions with long induction periods. Some reactions may proceed at ambient temperatures at a rate sufficient to produce some heat and toxic gases, but not at a rate to present a hazard to human health or the environment. Thus, in this analysis the definitions about heat generation and the toxic dusts, mists, fumes or gases, or flammable fumes or gases are qualified below to provide a definition specific to the OU 7-10 Glovebox Excavator Method Project:

Incompatible waste: means a hazardous waste that is unsuitable for commingling with another waste or material under uncontrolled conditions because the commingling might produce (extreme) heat (e.g., sufficient to cause a runaway reaction during storage) or pressure, fire or explosion, violent reaction, (or lead to the generation of) toxic dusts, mists, fumes, or gases, or flammable fumes or gases (at rates sufficient to constitute a threat to human health or the environment.)

Conclusions in this document about chemical compatibility are based on the qualified definition discussed above.

The qualified definition is consistent with the “General requirements for ignitable, reactive, or incompatible waste” located in 40 CFR 264.17(b). The general requirements direct facility operators who treat, store, or dispose ignitable or reactive waste, or who mix incompatible waste or incompatible waste and other materials, to take precautions to prevent reactions that will result in the following:

- Generate extreme heat or pressure, fire or explosions, or violent reactions;
- Produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to threaten human health or the environment;
- Produce uncontrolled flammable fumes or gases in sufficient quantities to pose a risk of fire or explosions
- Damage the structural integrity of the device or facility;
- Through other like means threaten human health or the environment.

Note the use of the qualifying terms such as “extreme” “uncontrolled,” and “adverse consequences.” The regulation allows mixing of incompatible waste or incompatible waste and other materials as long as the precautions taken ensure protection of human health and the environment and the avoidance of adverse consequences such as fire and explosive or violent reactions. Similarly, the qualified definition of incompatible waste presented above is based on the conclusion that commingled waste is

compatible if the uncontrolled commingling of the waste does not threaten human health or the environment and avoids adverse consequences such as fire and explosive or violent reactions.

3.1 Potassium and Sodium Nitrate ↔ Metals

The metals identified as presenting potential compatibility concerns in Table B-2 include beryllium, cadmium, chromium, lead, mercury, silver, and zirconium. In addition, plutonium, uranium, and calcium also are present. In the absence of heat, bulk metal will not react with sodium or potassium nitrate during packaging or storage. Powdered and finely divided metals are the basis of pyrotechnics and can react readily with potassium or sodium nitrate. Powdered or very finely divided cadmium, chromium, or zirconium should be mostly oxidized and no longer pyrophoric, but could be protected by a protective oxide coating which, if physically disrupted, might expose fresh metal surfaces. Calcium metal may be present but would not react with sodium or potassium nitrate because the latter alkali metals have a higher oxidation potential than calcium. Cadmium and chromium are known to react with fused ammonium nitrate below 200°C (392°F) (Bretherick 1991). It is implausible that unoxidized metal fines or powders would be unearthed during the OU 7-10 excavation. If unoxidized metal fines or powders were encountered, it would be prudent to package them separately from other waste.

The safety analysis for this project anticipates metal fires and project operations are prepared to suppress them.

3.2 Potassium and Sodium Nitrate ↔ Oils

A series of tests was performed at the Energetic Materials Research and Testing Center at the New Mexico Institute of Mining and Technology (commonly known as New Mexico Tech) in Socorro, New Mexico, to determine the reactions of nitrate salts with potential fuels when heated (Dick 2001). The greatest concern was the possibility of an explosive reaction between the nitrate salts present in the SDA in the form of Series 745 sludge and the large amount of oils present as Series 743 sludge. These are mainly Texaco Regal R&O or Shell Vitrea machining oils, cut with chlorinated solvents such as carbon tetrachloride, tetrachloroethene, trichloroethene, and 1,1,1-trichloroethane. The oils were packaged with calcium silicate to form a solid sludge at the RFP, but after many years in the SDA they may have separated because of decomposition, displacement by water, sedimentation, evaporation, or condensation.

Oils becoming mobile when heated, running into ruptured nitrate drums, and exploding during ISV constituted one scenario of concern. Nitrates melting and flowing into oil drums, and again possibly exploding when heated, constituted another scenario. Furthermore, the carbon tetrachloride, postulated to reduce the reactivity of the oils, may well have evaporated from the oil and migrated, as evidenced by the large amounts of carbon tetrachloride removed from the SDA by organic contamination in the vadose zone extraction methodology, and consequently not be available as a fire suppressant.

The ITRP performed preliminary tests to determine the explosive properties of nitrate salts when mixed with fuels (ITRP 1999). Mixtures of nitrates and 10% Regal Oil were tested for impact, static, and friction, without any initiations. A 1-gal mixture, when boosted with 150 g (5.3 oz) of Pentolite, did explode; however, the effects were estimated only by crater size. The Energetic Materials Research and Testing Center testers also were unable to cause explosions with mixtures of nitrates and oil.

Henkin and Koenen tests (Dick 2001) were conducted to determine critical explosion temperatures and violence of explosion under confinement. The Henkin and Koenen tests gave no explosions with the oil mixtures, even at the smallest orifice size in the Koenen test. The 5-gal container tests with oil, and with oil mixed with equal parts of carbon tetrachloride, only caught fire or smoked above 445°C (833°F). The drums were severely oxidized. The 55-gal drum test was heated for 1 week at 500°C (932°F) but did

not explode. At 500°C (932°F) the oil distilled from the drum with decomposition. It may be possible to find a lower temperature at which the oil would not migrate but would eventually react fast enough with the decomposing nitrate salts to explode. The intimate interface of oil-soaked nitrate provides a possible reaction zone. The consequences of such an explosion could be severe because several hundred pounds could be involved with a nitrate drum into which oil has flowed. The mixture of oil and sodium or potassium nitrates is similar to ammonium nitrate fuel oil explosives; however, in the case of ammonium nitrate the compound can explode without any oil present. The diesel fuel sensitizes the ammonium nitrate and adds to the explosive energy, but is not necessary for an explosion. While not applicable to ambient temperature compatibility, attention is called to the potential hazard of any heat treatment of packaged drums.

In another test, the mixture of oil and nitrates did not ignite when the heaters arced and burned holes in the 5-gal drum. Burn rate tests were performed at the Energetic Materials Research and Testing Center to determine the flame propagation properties of nitrate salt mixtures. In the burn-rate tests, the nitrate and oil mixtures failed to ignite from a hot wire and propagate a flame front (Dick 2001).

During one blending of the oil with the nitrate test mixture in the drum tumbler, some of the mixture oozed from the mixing drum lid threads. The possibility of a chemical reaction was considered, but rejected because no heating or gas evolution was observed. The yellowing of the mixture was ascribed to traces of chromophores in the oil. After the mixtures were transported to the firing sites and poured into the 5- and 55-gal test containers, no heat or gas evolution was detected. During the heating at a rate of 100°C (212°F) increase per hour, evolution of CO, CO₂, NO, and NO₂ was observed, but no runaway reactions were experienced. No exothermicity was noted between 25 and 240°C (77 and 464°F), and mild exothermicity was noted in the radial thermocouple in the time versus temperature plots above 240°C (464°F).

At ambient temperatures, it is implausible that the nitrate salts will react with oils to produce either an explosion or a fire; therefore, they are not incompatible.

3.3 Potassium and Sodium Nitrate ↔ Graphite

A nitrate mixture with 20-wt% graphite did not explode up to the maximum attainable temperature of 398°C (849°F) in the Henkin test. In the Koenen test, a 20-wt% graphite mixture resulted in a limiting diameter of 3 mm (0.1 in.), meaning the reaction fragmented the sample tubes. If the tests had been run for United Nations qualification of the material, the results would have been positive, meaning the material showed a violent effect on heating under confinement.

Graphite did not explode, but did burn on both the 5- and 55-gal scale when nitrate salts in an 80 to 20-wt% ratio were placed on top of the graphite and the drum was heated. The intense heat of the fires melted the drums. In Test 19, where the graphite and nitrate salts were mixed 100 turns, the reaction was energetic and rapid enough to disrupt the surface of the ground.

After mixing, the graphite and nitrate test mixtures were transported to the firing site and poured into the 5- and 55-gal test containers. No heat or gas evolution was noted and no attempt was made to monitor gas evolution during heating. The plots of time versus temperature for Test 19 shown in Appendix B (p. B-22) and Test 26 (p. B-33) of Dick (2001) clearly show no exothermicity from 25 to 500°C (77 to 932°F).

The Henkin and Koenen tests for critical explosion temperature and violence under confinement represent the worst-case scenarios because the drums actually present in the SDA contain mostly graphite pieces and are unlikely to contain all fines or scarfings. Nitrates in contact with graphite, as is the case

with oil, provide opportunities for large explosive quantities in one drum. It must be noted that sodium nitrate is deliquescent; it will absorb moisture from its surroundings until it dissolves in the absorbed moisture. Further discussions of sodium nitrate deliquescence can be found in the *Yucca Mountain Science and Engineering Report Technical Information Supporting Site Recommendation Consideration* (DOE 2001). Tables of relative aqueous-vapor pressures of various mixtures of solids, and of solids with their saturated solutions, are available from the work of N. Schoorl (Schoorl 1952; Kolthoff and Sandell 1952). Based on information from a draft memo from Michael J. Rohe,^f relative humidity in the vadose zone is close to 100%. Like gunpowder, nitrate mixtures will not burn rapidly or explode if wet. The ITRP concluded that explosions are beyond extremely unlikely if the moisture content is greater than 5 wt%, based on the failure to obtain an explosive yield even with a Pentolite booster when the moisture content was 5 wt% in the mixture with oil (ITRP 1999).

At ambient temperatures, it is implausible that nitrate salts will react with graphite to produce either an explosion or a fire; therefore, the mixture is not incompatible. Nevertheless, the mixture could be ignited by an ignition source

3.4 Potassium and Sodium Nitrate ↔ Halogenated Organics (Carbon Tetrachloride, Chloroform, Methylene Chloride, Tetrachloroethene, Trichloroethene, 1,1,1-Trichloroethane, and Freon 113)

Nitrates will not react with halocarbons at ambient temperatures. A carbon tetrachloride and oil mixture smoked but did not take fire when heated to 500°C (932°F) with a mixture of sodium and potassium nitrate (Dick 2001). After mixing, the oil, carbon tetrachloride, and nitrate, test mixtures were transported to the firing site and poured into the 5- and 55-gal test containers. No heat or gas evolution was noted. A yellowing of the mixture was noted and ascribed to traces of chromophores. During the heating at a rate of 100°C (212°F) increase per hour, evolution of CO, CO₂, NO, and NO₂ was observed, but no runaway reactions were experienced.

According to the ITRP report, “Organic chloride solvents are all fire suppressants; therefore, the pure oil and nitrate mixture is clearly a bounding scenario” (ITRP 1999, p. 13). Thus, any mixture with perchlorinated solvents should exhibit less reactivity than with the pure oil. Carbon tetrachloride has been employed as a fire extinguisher but has the disadvantage of forming phosgene at high temperatures. Nitrogen dioxide and dinitrogen tetroxide undergo explosive reactions with unsaturated chlorocarbons such as tetrachloroethene and trichloroethene, but heating to well above 200°C (392°F) would be necessary to decompose the nitrates to yield NO₂. Under ambient storage conditions, nitrate salts will not react with the halocarbons listed above and the mixtures are not incompatible.

The possibility of phosgene generation was considered. Carbon tetrachloride will react with oxygen at elevated temperatures (such as in a fire) to form phosgene (COCl₂). A similar reaction of carbon tetrachloride with nitrates was considered; the reaction does not proceed at ambient temperatures. Phosgene is a nonpersistent war gas and rapidly reacts with moisture to form carbon dioxide and hydrogen chloride, which renders it not useful for attacks in rain or fog. It would react rapidly with moisture in the interstitial dirt or with water in the deluge system in the event of a fire.

f. Michael J. Rohe Personal Memorandum to George A. Beitel, “Relative Humidity in Vadose Zone Cavity (Draft),” January 18, 2002, Idaho National Engineering and Environmental laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.

3.5 Potassium and Sodium Nitrate ↔ Rags

Nitrate salts can react with cellulose materials. Bretherick reported jute bags of nitrates catching fire on board a ship in the tropics (Bretherick 1991) and flash paper is made by impregnating paper with nitrate solutions. During the explosives tests in New Mexico, nitrate salts placed on top of dry rags and Kimwipes and heated above 300°C (572°F) underwent a temperature excursion that caused the lids and bottoms to bulge but showed no evidence of an explosion (Dick 2001). Nitrate-soaked rags and Kimwipes exploded in these tests and at lower temperatures than the nitrates on top of pyrolyzed rags. The explosive effects were less because only 30 kg (66 lb) of soaked and dried rags could be forced into a 55-gal drum. A drum was ignited with a hot wire and exploded at a temperature of only 150°C (302°F). Again, this was a worst-case and highly implausible scenario. The 65-wt% nitrate ratio was chosen as the highest nitrate concentration that could be achieved by the ITRP in its tests (ITRP 1999). During testing, this concentration could be achieved only by soaking the rags in a saturated nitrate solution at 60°C (140°F). The stoichiometric ratio for burning-to-CO₂ would be closer to 73% nitrates. It should be noted, however, that the 52% nitrate-soaked rags in Test 12d burned 25% faster than the 63% nitrate-soaked rags in Test 12c. Cheetah computer code (LLNL 1998) calculations indicate a rather broad range over which the nitrate-soaked rags can burn or deflagrate. It is not difficult to construct a scenario in which nitrate salts are dissolved from drums in the SDA and transported in solution to rag-filled drums. However, it would be difficult for the wet rags to dry to such a concentration of nitrates underground. It is implausible that any rags in the SDA would be dry; nevertheless, it would be prudent to separate them. If the packaged waste underwent subsequent heat treatment, then dried nitrate-soaked rags would be a concern.

After drying, the nitrate-soaked rags were transported to the firing site and placed into the 5- and 55-gal test containers. No heat or gas evolution was noted. During the heating at a rate of 100°C (212°F) increase per hour, evolution of CO, CO₂, NO, and NO₂ was observed.

Nitrate salt mixtures with cellulose did not pass the test for exclusion from the U.S. Department of Transportation Class 5, Division 5.1, oxidizer status when the salts were diluted with 20% soil or 25% water. The addition of 30% water did result in a pass.^g

Nitrate salts combined with rags or tissues would not result in a chemical incompatibility at ambient temperatures. If the packaged waste underwent subsequent heat treatment, then dried nitrate-soaked rags would present a reactivity concern.

3.6 Potassium and Sodium Nitrate ↔ Nitrobenzene

Nitrates could react with nitrobenzene only in strong nitric acid with heating. The reaction to form meta-dinitrobenzene is endothermic and would not occur in the conditions currently existing in the SDA. Moreover, nitrobenzene is present, if at all, in minimal quantities.

g. Peter G. Shaw E-mail to James J. Jessmore, May 6, 1999 (forwarded E-mail from Vince Mendoza, Stresau Labs, to Reva Hyde, Idaho National Engineering and Environmental Laboratory), "Preliminary Test Results, INEEL Soil Sample Oxidizer Tests," Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.

3.7 Potassium and Sodium Nitrate ↔ Organic Acids, Alcohols, Ethylenediaminetetraacetic Acid, Acetone, and Xylene

In addressing the emplacement of Stage I probe holes, the ITRP concluded that reactions between nitrate salts and other organics is not a credible threat because they cannot come into contact in sufficient concentrations to produce an energetic event (ITRP 1999):

Second, for the concern that nitrates from 745-sludge may mix with organics in the 744-sludge, the alcohols, organic acids, and EDTA were mixed with Portland and magnesia cements, then covered with more Portland cement to form the 744-sludge (Ref. 14). In such a matrix, the organic acids would be tightly bound to the alkaline cement and the water-soluble alcohols would be solvated in the matrix like water. This would preclude their migration into nitrate sludge to form an explosive mixture. Third, although other organic compounds, such as butyl alcohol, xylenes, and acetone, are reported to be in Pit 9, the quantities are in parts per million and are of no concern because that level of concentration is insufficient to form a detonatable mixture with the nitrate sludge (Refs. 15 and 16).

No reactions have been hypothesized that could lead to explosion, rupture, or fumes even if the chemicals listed above were to become commingled; therefore, the mixtures are not incompatible.

3.8 Lithium Oxide ↔ Halogenated Organics (Carbon Tetrachloride, Chloroform, Methylene Chloride, Tetrachloroethene, Trichloroethene, 1,1,1-Trichloroethane, and Freon 113)

As stated in the inventory documentation (Einerson and Thomas 1999), lithium oxide is the compound assumed to be associated with lithium battery waste from the RFP. The batteries were occasionally placed in some Series 742 sludge drums (Clements 1982).

Lithium oxide is likely now in a carbonate form that does not present a potential for chemical incompatibility. Lithium carbonate does cause dehydrohalogenation when the reactants are heated in dimethylformamide; however, the reaction is endothermic and not applicable to the present case. Lithium oxide reacts with water to form the alkaline hydroxide. Strongly alkaline solutions have been reported to react with liquid trichloroethene to result in flames and explosion, possibly by the generation of dichloroacetylene (Bretherick 1991). Lithium hydroxide also could cause nucleophilic substitution by alcohols but the reaction would be mild and endothermic, and would not meet the definition of incompatible. A previous evaluation of the chemical compatibility considerations associated with the lithium batteries was documented in 1990 for the transuranic stored waste at the RWMC (Hefta 1990). The conclusion was that "...although elemental lithium is clearly incompatible with many other reaction groups, the possibility of a rapid violent reaction occurring is very remote and the possibility of container damage resulting from such a reaction is even more remote. Waste segregation of Content Code 002 is not necessary."

3.9 Lithium Oxide ↔ Alcohols (Butyl and Methyl), Acetone, and Xylene

Lithium oxide is likely now in a carbonate form that does not present a potential for chemical incompatibility. Lithium oxide or hydroxide are basic and could cause aldol condensations in acetone.

This would not be a hazardous reaction. Lithium oxide could react with alcohols to form the alkoxides but the reaction would not be violent; therefore, the mixtures are not incompatible.

3.10 Lithium Oxide ↔ Nitrobenzene

Strong bases (e.g., lithium hydroxide), when heated with nitrobenzene, can result in an explosion. Nitrobenzene is present only in trace quantities, if at all, in OU 7-10.

3.11 Beryllium ↔ Alcohols (Butyl and Methyl)

Beryllium does react with alcohols to form alkoxides, but the alcohols are not present in sufficient concentration within OU 7-10 for a reaction to occur. Acetone and xylene would not react.

3.12 Potassium and Sodium Dichromate ↔ All Other Groupings

As shown on Table B-2, potassium and sodium dichromate have been identified as potentially exhibiting incompatibility in the following combinations:

- Potassium and sodium dichromate ↔ metals (beryllium, cadmium, chromium, lead, mercury, silver, and zirconium)
- Potassium and sodium dichromate ↔ organic acids
- Potassium and sodium dichromate ↔ EDTA
- Potassium and sodium dichromate ↔ halogenated organics (carbon tetrachloride, chloroform, methylene chloride, tetrachloroethene, Freon 113, 1,1,1-trichloroethane, and trichloroethene)
- Potassium and sodium dichromate ↔ alcohols and ketones (butyl alcohol, methyl alcohol, acetone, and xylene)
- Potassium and sodium dichromate ↔ nitrobenzene
- Potassium and sodium dichromate ↔ graphite.

The Series 745 sludge waste stream contains the dichromates. The concentrations of dichromates have been estimated at approximately 400 ppm (Einerson and Thomas 1999). The estimate is based on analytical results obtained during the remedial investigation and feasibility study process for Pad A. Detailed evaluation of each chemical interaction is not viewed as warranted because of the low concentration of dichromates. At a concentration in the approximate range of 400 ppm, no reasonable potential for an adverse chemical reaction exists in the event that the nitrate salts containing the dichromates come in contact with the various chemicals identified above. At a concentration of only 0.04%, any reaction effects would be quenched, absorbed, and dissipated by the other 99.96 % of bulk materials present.

3.13 Organic Acids ↔ All Other Groupings

As shown on Table B-2, organic acids have been identified as potentially exhibiting incompatibility in the following combinations:

- Organic acids ↔ metals (beryllium, cadmium, chromium, lead, mercury, silver, and zirconium)

- Organic acids ↔ sodium and potassium nitrate
- Organic acids ↔ sodium and potassium dichromate
- Organic acids ↔ EDTA
- Organic acids ↔ halogenated organics (carbon tetrachloride, chloroform, methylene chloride, tetrachloroethene, Freon 113, 1,1,1-trichloroethane, and trichloroethene)
- Organic acids ↔ alcohols and ketones (butyl alcohol, methyl alcohol, acetone, and xylene)
- Organic acids ↔ sodium cyanide.

The organic acids are associated with Series 744 sludge. The sludge formulation and packaging descriptions for the Series 744 sludge is described in Section 1 and Appendix A. As shown in the inventory documentation, the organic acid contained in the Series 744 sludge is believed to be ascorbic acid (Einerson and Thomas 1999). Process knowledge information indicates that the Series 744 sludge waste stream consists of liquids absorbed in a cement mixture. The liquid waste was made basic or neutralized before being added to the cement mixture (Clements 1982) (see Appendix A for Content Code 4).

The EDTAs are organic acids and therefore would not react with other organic acids. Organic acids could react with alcohols to form esters but this would not be a hazardous product. Organic acids could provide the hydrogen ions necessary to liberate hydrogen cyanide from sodium cyanide. However, as stated above, they are incorporated as the neutralized salt in the cement and unable to donate protons.

Based on the neutralization of the weak acids at RFP and the physical configuration of the Series 744 sludge (i.e., a cemented monolith), no reasonable potential for an adverse chemical reaction exists in the event that the organic acids (i.e., Series 744 sludge) come in contact with any of the chemicals identified above or are jointly packaged into a drum.

3.14 EDTA ↔ All Other Groupings

As shown on Table B-2, EDTA has been identified as potentially exhibiting incompatibility in the following combinations:

- EDTA ↔ sodium and potassium nitrate (see Section 3.7)
- EDTA ↔ sodium and potassium dichromate (see Section 3.12)
- EDTA ↔ organic acids (see Section 3.13)
- EDTA ↔ lithium oxide.

Also associated with Series 744 sludge is EDTA. Sludge formulation and packaging descriptions for the Series 744 sludge is described in Section 1 and Appendix A. As shown in the inventory documentation, the Versene contained in the Series 744 sludge is EDTA (Einerson and Thomas 1999). Process knowledge information indicates that the Series 744 waste stream consists of liquids absorbed in a cement mixture. The liquid waste was made basic or neutralized before adding it to the cement mixture (Clements 1982) (see Appendix A for Content Code 4).

Even if the EDTA were available for reaction, it would not undergo any dangerous reactions with the chemicals listed above. The EDTA is already an acid and would not react with other acids. Reaction with lithium oxide would only form lithium salt. Reaction with alcohols would form esters.

3.15 Plutonium and Plutonium Oxide ↔ Air

Unoxidized plutonium metal could still exist in OU 7-10.^h An oxide coating would be expected to be covering the plutonium metal; however, disruption of the coating could lead to a smoldering plutonium fire if a mixture of plutonium oxide and plutonium hydride were present on the surface and ignited. Plutonium forms sesquioxides (Pu_2O_3) as well as the most stable dioxide (PuO_2) (DOE-HDBK-1081-94; DOE 1994). Therefore, depending on the conditions, even though all plutonium may have oxidized, a pyrophoric coating of oxides and hydrides could have formed in the presence of air and moisture. These could ignite on exposure to air.

3.16 Uranium and Uranium Oxide ↔ Air

Unoxidized uranium could still exist in OU 7-10 (see footnote h). An oxide coating would be expected to be covering the uranium metal; however, disruption of the coating could lead to a uranium fire if a mixture of uranium oxide and uranium hydride were present on the surface and ignited. Uranium forms sesquioxides (UO_2 and U_2O_5) as well as the more stable trioxide (UO_3). Therefore, depending on the conditions, even though all uranium may have oxidized, a pyrophoric coating of oxides and hydrides could have formed in the presence of air and moisture. These could ignite when exposed to air as could any unoxidized uranium metal. The roasting process was intended to convert all metal to U_3O_8 , but chunks of uranium metal have been found in drums of roaster oxide.

h. John R. Dick Personal Conversation with James D. Navratil, July 1999, "Existence of Plutonium Metal in Pit 9," Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.

4. CHEMICAL COMPATIBILITY EVALUATION, SUMMARY, AND CONCLUSIONS

An examination of all of the binary combinations of the chemicals known to be in the project area resulted in no anticipated or postulated reactions that could lead to explosion, rupturing of containers, fire, or uncontrolled hazardous fumes; therefore, the combinations are not incompatible for repackaging and storage at ambient temperatures.

If the packaged waste containers were treated by heating to elevated temperatures, the possibility of reactivity cannot be excluded. Combinations of nitrates with carbonaceous materials such as charcoal, graphite, and cellulose have been shown by testing to react vigorously at temperatures in excess of 200°C (392°F). Thresholds of nitrates that may cause undesirable reactivity were not determined by previous testing.

The evaluation did not rule out the possibility of slow reactions at ambient temperatures or reactions after an induction period. However it did conclude that reactions leading to heat buildup and a runaway reaction, fire, explosion, or uncontrolled releases of toxic gases at a rate sufficient to constitute a danger to human health or the environment would not occur without a strong external heat source. Testing in 55-gal containers heated at a rate of 100°C (212°) increase per hour did not result in runaway reactions at temperatures less than 200°C (392°); however, nitrate-soaked rags did deflagrate when ignited with a hot wire at 150°C (306°F).

The establishment of a 5 wt% moisture level as a limit for nitrate-oil explosions is based on actual test results obtained by the ITRP. The corollary guidance about fires versus moisture content is based on expert opinion, again by the ITRP. The moisture in the interstitial soil thus further reduces the possibility of fire and explosion at ambient temperatures. If the moisture were removed by heat treatment, the protective effect would no longer exist.

Unreported and incomplete U.S. Department of Transportation oxidizer tests neither substantiate nor negate the conclusions about nitrate reactivity. Without additional testing and development of a quick in situ test for nitrates in soils, the functioning of nitrates as an oxidizer cannot be totally excluded.

5. ADDITIONAL ACTIVITIES TO ENHANCE DEFENSE IN DEPTH

This section presents a number of activities that can be considered to enhance defense in depth of project operations:

- Package like materials together to the extent practicable.
- Separate any visually observable finely divided (e.g., shavings, turnings, and filings) or powdered metals.
- Separate rags and tissues (if still intact) from sludges and soils (pending).
- Handle any sealed bottles or sealed small metal containers as potentially pyrophoric.
- Implement field screening to identify materials with potential nitrate salts. Determine a nitrate concentration below which the material would not exhibit the reactivity characteristic as defined by RCRA. Differential scanning calorimetry may prove effective at determining reactivity.
- Consider the addition of interstitial soil from the work site to further reduce the reactivity potential.
- Maintain adequate fire extinguishing capabilities including magnesium oxide sand for plutonium (Felt 1967; AEC 1955).

6. REFERENCES

- 40 CFR 264.13, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Activities," Subpart B, "General Facility Standards," Section 264.13, "General Waste Analysis," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 264.15, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart B, "General Facility Standards," Section 264.15, "General Inspection Requirements," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 264.16, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart B, "General Facility Standards," Section 264.16, "Personnel Training," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 264.17, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart B, "General Facility Standards," Section 264.17, "General Requirements for Ignitable, Reactive, or Incompatible Wastes," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 264.31, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart B, "General Facility Standards," Section 264.31, "Design and Operation of Facility," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 264.35, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart B, "General Facility Standards," Section 264.35, "Required Aisle Space," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 264 Subpart I, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart I, "Use and Management of Containers," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 264.172, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart I, "Use and Management of Containers," Section 264.172, "Compatibility of Waste with Containers," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 264.176, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart I, "Use and Management of Containers," Section 264.176, "Special Requirements for Ignitable or Reactive Waste," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 264.177, 2002, Title 40, "Protection of Environment," Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart I, "Use and Management of Containers," Section 264.177, "Special Requirements for Incompatible Wastes," *Code of Federal Regulations*, Office of the Federal Register.

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Appendix A

Content Code Assessments for Idaho National Engineering Laboratory Contact-Handled Stored Transuranic Waste

Appendix A

Content Code Assessments for Idaho National Engineering and Environmental Laboratory Contact-Handled Stored Transuranic Waste

Appendix A contains a copy of *Content Code Assessments for INEL Contact-Handled Stored Transuranic Wastes* (Clements 1982), which includes waste description and packaging information important to the evaluation of chemical compatibilities.

Report No. WM-FI-82-021

Date: October 1982

PATENT CLEARED

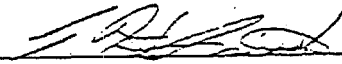
CONTENT CODE ASSESSMENTS FOR INEL CONTACT-HANDLED
STORED TRANSURANIC WASTES

Waste Programs Division

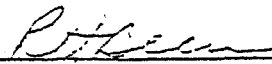
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Thomas L. Clements, Jr.

Checked By:



Approved By:



14-0156365 LIMIT

3.3 Content Code 1

Content Description: Combined Sludge (prefix 7412)

Generator: Rocky Flats Plant

Waste Description: Waste consists of combined first-stage and second-stage sludge. Combining sludges began during the fall of 1979 to reduce radiation levels associated with first-stage sludge. Portland cement is added to the waste package for absorption of free liquids.

Combined sludge is shipped to the INEL as Content Code 1 waste. All waste drums received since 1979 and labeled as Content Code 1 should contain combined sludge only.

Generation Source: Aqueous Waste Treatment (Building 774)

Waste Form: See waste assessments for Content Codes 1 (first-stage sludge) and 2 (second-stage sludge).

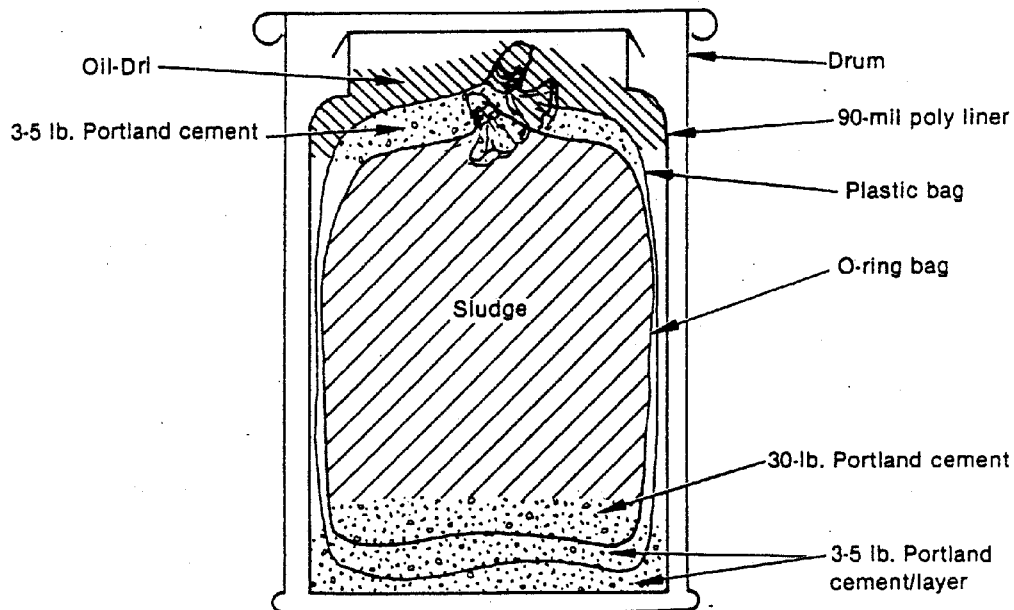
Recovery Method: None. Liquid wastes are analyzed for fissile content prior to release from various plant buildings to Building 774 for treatment. Liquid wastes contaminated with above-discard amounts of plutonium are processed by plutonium recovery operation (Building 771) before release to Building 774.

Waste Packaging and Handling: Combined sludges are packaged as shown in Figure 2. Portland cement is added, as shown, to ensure absorption of a free liquids that may be generated from the sludge. The total quantity of cement added may range up to 40 or 50 lb.

Drum Preparation: See Figure 2.

Assay: Assay values are obtained by recording the weekly quantity of transuranic material in liquid waste transferred to Building 744 for processing. This value is then averaged over the number of sludge drums generated that week. Waste drums are then transported to the Size

1979-1982: Since 1979, the first stage and second stage sludges have been combined.



Spring 1982 - Present: Portland cement is now added on top of the sludge before closing the O-ring bag.

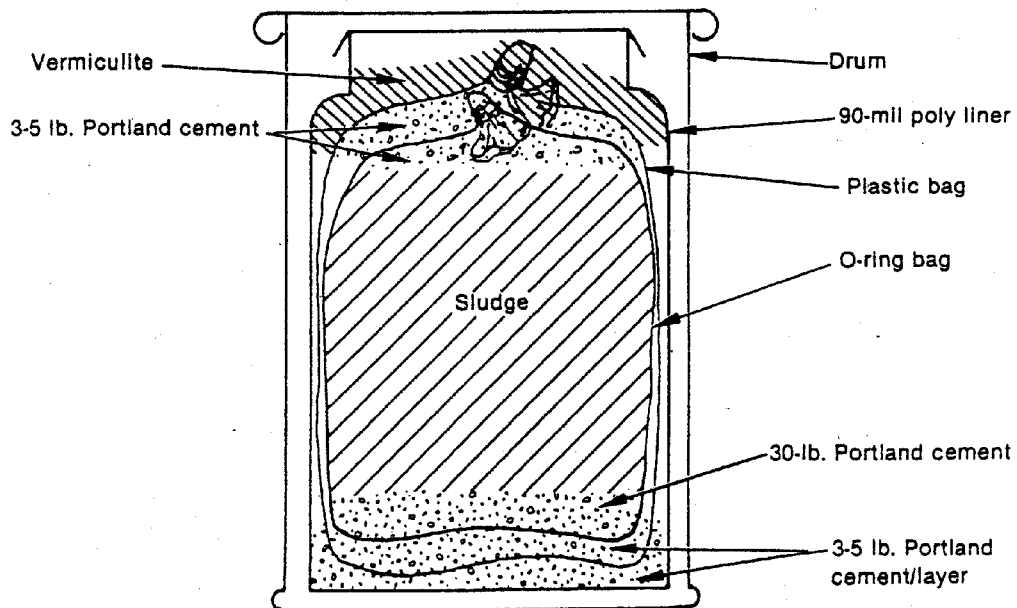


Figure 2. Combined sludge packaging methods.

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Reduction Facility (Building 776) for inspection and sealing.

Inspection: Drums are inspected for free liquids, proper packaging, and use of the proper content code. Rejected drums are returned to the waste generator for correction. After inspection, 1 to 2 quarts of absorbent material (trade name Oil-Dri) were placed on top of the outer, sealed-polyethylene drum bag. This procedure was changed in February 1982. Vermiculite is now used to fill the remaining space between the outer, sealed polyethylene drum bag and the top of the 90-mil rigid liner. Depending on the amount of waste in the drum, the quantity of vermiculite added may range from 3 to 12 lb.

The rigid liner lid is then sealed on the rigid liner. The 55-gallon drum lid and gasket are then installed and secured with a lock-chine.

Waste Generator Contacts:

J. L. DiRocchi
P. T. Godesiaboïs
M. E. Maas

Record Information: INEL-TCWCIS

Information (1971-81) ^a		Drums	Boxes
Total Containers		7750	0
Container Weight (lb)	Maximum:	933.0	
	Minimum:	118.0	
	Average:	490.0	
Contact Dose Rate (mR/h)	<10:	2640	
	10-200:	5110	
	Maximum:	195.0	
	Minimum:	0.0	
	Average:	22.9	

a. Information includes first-stage sludge and combined sludge.

Radionuclide Inventory

Plutonium (g)	Maximum:	157.0
	Minimum:	0.0
	Average:	4.3
Americium (g)	Maximum:	52.9
	Minimum:	0.0
	Average:	1.8

Waste Form Evaluation:

Gas Generation--While organic content should be less than 14 lb/ft³, the waste may generate gas due to radiological breakdown of water and nitrates. Pressurized drums will require venting prior to shipping.

Combustibles--Combustibles comprise less than 25 volume percent of the waste. Color coding will not be required.

Immobilization--The sludge is an amorphous, semisolid material containing 50 to 70 weight percent water. No respirable or dispersible fines should be present. Portland cement added to the waste as absorbent is not considered particulate material.

Sludges--The waste is sludge. Corrosion protection has been provided by the layers of plastic used for containment of the sludge.

Free Liquid--The sludge contains 50 to 70 weight percent water when packaged. Portland cement is placed in the drum to absorb any free liquid that may form from the sludge. Drums packaged prior to the spring of 1982 may have free liquids. Separation of water from the sludge may occur between the top of the sludge and the O-ring bag. Currently, cement is added on top of the sludge before the O-ring bag is sealed, precluding formation of free liquids.

Drums containing free liquids are not certifiable.

Explosives/Compressed Gases--No explosives, explosive mixtures, or compressed gases (49CFR173, Subparts C and G) have been identified in this waste.

Pyrophoric Materials--No pyrophoric materials (49CFR173, Subparts D and E) have been identified in this waste.

Toxic/Corrosive Materials--No reportable quantities of corrosive materials (49CFR173, Subpart F) have been identified in this waste. Past analysis of combined sludge samples indicates beryllium concentrations may range up to 1000 ppm.

Certification Assessment: Waste is certifiable except for any drums containing free liquids.

3.4 Content Code 2

Content Description: Second-Stage Sludge (prefix 742)

Generator: Rocky Flats Plant

Waste Description: Waste consists of a wet sludge produced from treatment of all other plant radioactive and/or chemical contaminated wastes and further treatment of the first-stage effluent. Portland cement was added to the waste package for absorption of free liquids.

Second-stage sludge drums packaged prior to 1973 may contain other waste such as electric motors, bottles of chemical (usually liquid) wastes, mercury and lithium batteries, and small amounts of contaminated mercury in pint bottles. Radioactive sources were also periodically included in second-stage drums through 1979.

Since the fall of 1979, second-stage sludges have been combined with first-stage sludge. The combined sludge is shipped to the INEL as Content Code 1. Content Code 2 is no longer used.

Generation Source: Aqueous Waste Treatment (Building 774).

Waste Form: Sludge is produced by treating aqueous wastes by the carrier precipitation process. Aqueous wastes are made basic, if necessary, with sodium hydroxide. Radioactive elements such as plutonium and americium are then chemically precipitated from the liquid waste. Treatment chemicals include ferric sulfate, calcium chloride, magnesium sulfate, and flocculating agents. The treatment process produces a precipitate of the hydrated oxides of iron, magnesium, aluminum, silicon, etc., which also carries the hydrated oxides of plutonium and americium. The precipitate or slurry is filtered to produce a sludge containing 50 to 70 weight percent water.

Recovery Method: None. Liquid wastes were analyzed for fissile content prior to release from various buildings to Building 774. Liquid wastes were sent to Plutonium Recovery Operations (Building 771) for further treatment if contaminated with above-discard amounts of plutonium.

Waste Packaging and Handling: Second-stage sludge was packaged as shown in Figure 3. Portland cement was added, as shown, to ensure absorption of any free liquids that might be formed from the sludge. The total quantity of cement added could range up to 40 or 50 lb.

Drum Preparation: See Figure 3.

Assay: Assay values for second-stage sludge drums were obtained by taking a composite sample of all drums generated during one day. The composite sludge sample was radiochemically analyzed and the results were then averaged for all drums in the sample. Waste drums were then transported to the Size Reduction Facility (Building 776) for inspection and sealing.

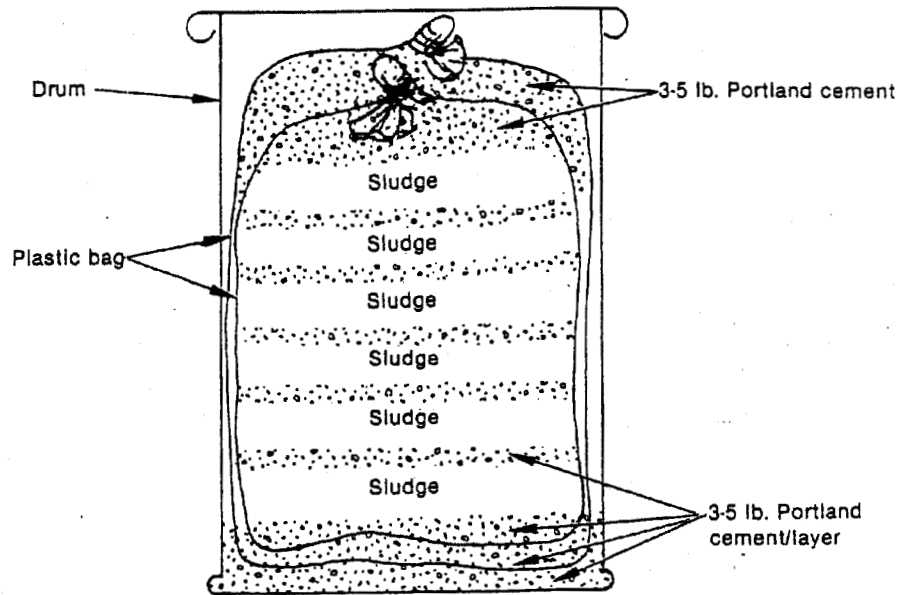
Inspection: Since approximately 1972, drums have been inspected for free liquids, proper packaging, and use of the proper content code. Rejected drums are returned to the waste generator for correction. After inspection, 1 to 2 quarts of absorbent material (trade name Oil-Dri) were placed on top of the outer sealed polyethylene drum bag.

The rigid liner lid was then sealed on the rigid liner (if applicable). The 55-gallon drum lid and gasket were installed and secured with a lock-chine.

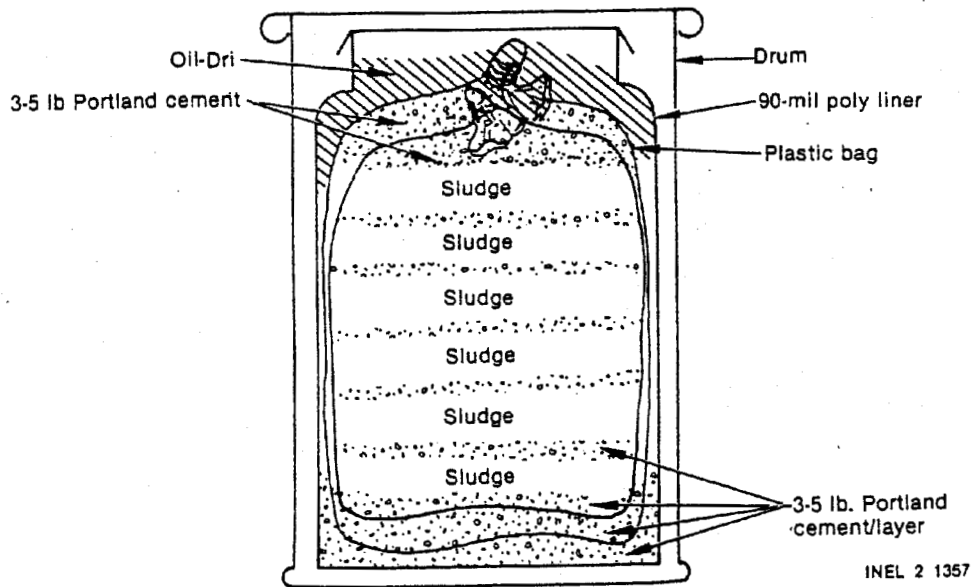
Waste Generator Contacts:

J. L. DiRocchi
P. T. Godesiaboïs
M. E. Maas

1970 - 1972:



1972 - 1979: In 1972, use of the 90-mil polyethylene drum liner began.



INEL 2 1357

Figure 3. Second stage sludge packaging mehtods.

Record Information: INEL-TCWCIS

<u>Information (1971-81)</u>		<u>Drums</u>	<u>Boxes</u>
Total Containers		7688	0
Container Weight (lb)	Maximum:	952.0	
	Minimum:	210	
	Average:	528	
Contact Dose Rate (mR/h)	<10:	7681	
	10-200:	7	
	Maximum:	27.0	
	Minimum:	0.0	
	Average:	0.7	
Radionuclide Inventory			
Plutonium (g)	Maximum:	8.9	
	Minimum:	0.0	
	Average:	0.2	
Americium (g)	Maximum:	7.1	
	Minimum:	0.0	
	Average:	0.0	

Waste Form Evaluation:

Gas Generation--Organic content should be less than 14 lb/ft³.

Some gas may be generated due to radiological breakdown of water and nitrates. Any pressurized drums will be vented prior to shipping.

Combustibles--Combustible content should be less than 25 volume percent. Color coding is not required.

Immobilization--Waste is an amorphous, semisolid material containing 50 to 70 weight percent water. No respirable or dispersible fines should be present. Portland cement added to the waste as absorbent is not considered particulate material.

Sludges--Waste is sludge. Corrosion protection has been provided by the layers of plastic used for containment of the sludge.

Free Liquid--Sludge contained 50 to 70 weight percent water. Portland cement was added to the drum as it was filled with sludge. No free liquids should be present.

Drums packaged prior to 1973 could contain bottles of liquid chemical wastes.

Explosive/Compressed Gases--No explosives, explosive mixtures, or compressed gases (49CFR173, Subparts C and G) have been identified in this waste.

Pyrophoric Materials--No pyrophoric materials (49CFR173, Subparts D and E) have been identified in this waste.

Toxic/Corrosive Materials--No reportable quantities of toxic or corrosive materials (49CFR173, Subparts H and F) have been identified in this waste. Drums packaged before 1973 could include bottles of liquid wastes. These wastes could include reportable quantities of toxic materials. Specific information is not available.

Certification Assessment: Waste is certifiable. Any waste that contains bottles of liquid waste is not certifiable.

3.5 Content Code 3

Content Description: Organic Setups (prefix 743)

Generator: Rocky Flats Plant

Waste Description: Organic setups are produced from treatment of liquid organic wastes generated by various plutonium and nonplutonium operations. The organic wastes are mixed with calcium silicate to form a grease or paste-like material. Small amounts of Oil-Dri (trade name) absorbent are ususally mixed with the waste.

Generation Source: Organic wastes, which are generated by various plutonium and nonplutonium areas, are processed by Aqueous Waste Treatment (Building 774).

Waste Form: Organic wastes such as degreasing agents (primarily trichloroethane), lathe coolant (machining oil and carbon tetrachloride), and hydraulic oils are generated primarily by plutonium fabrication operations. Other organic wastes include carbon tetrachloride; trichloroethylene; tetrachloroethylene; hydraulic, gearbox, and spindle oils; and trace concentrations of miscellaneous organic laboratory wastes (organophosphates, nitrobenzene, etc.). In addition, unknown volumes of oil containing polychlorinated biphenyls (PCB) were processed with other organic wastes until 1979. Degreasing solvents generated by Building 444 operations are contaminated with beryllium. The following information concerning major types of organic liquids, and quantities processed each month was provided:

<u>Organic Liquid</u>	<u>Gallons/Month</u>	<u>% of Total</u>
Lathe coolant--60% Texaco Regal oil, 40% carbon tetrachloride	700	47
Trichloroethane	150	10
Miscellaneous--hydraulic oil, gearbox oil, spindle oil, Freon, Varsol, etc.	650	43
TOTAL	1500	100

Recovery Method: Only below-discard contaminated organic wastes are processed at Building 774. Organic wastes are analyzed prior to release to Building 774 for processing. Above-discard contaminated organic wastes are filtered until the waste is determined to contain discardable amounts of plutonium.

Waste Packaging and Handling: Liquid organic wastes are collected by pipeline for processing in a common tank or are received in batch quantities contained in bottles or drums. The liquids are processed by blending approximately 30 gallons of organic wastes with 100 lb of calcium silicate (Johns-Manville product, Microcel E) in a continuous mixer to form a solid-like paste or "grease." Small amounts (10 to 20 lb) of Oil-Dri are usually mixed with the waste. The waste is packaged as shown in Figure 4.

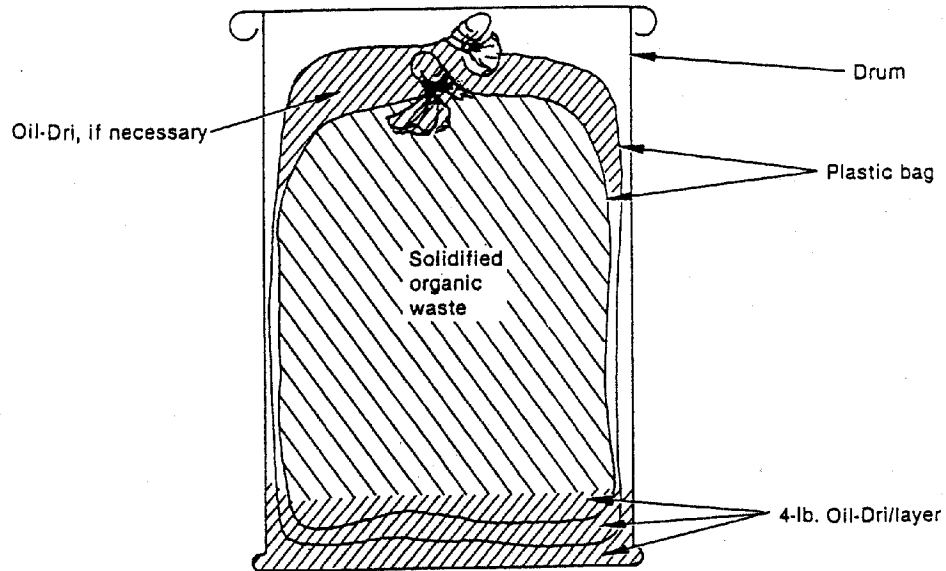
Drum Preparation: See Figure 4. The total quantity of Oil-Dri added during packaging (excluding that added to the organic waste and during drum inspection) is estimated at 15 to 20 lb.

Assay: Assay values for waste drums are obtained from radiochemical analyses of batch treatments, and/or analysis or assay results of individual bottles and drums received for processing. Average values are usually assigned to waste drums. Waste drums are then transported to the Size Reduction Facility (Building 776) for inspection and sealing.

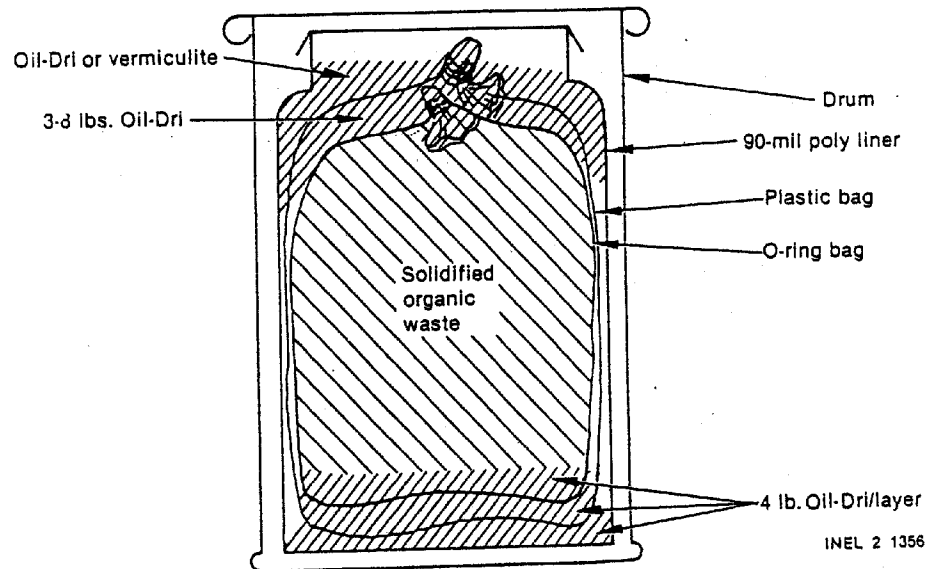
Inspection: Since approximately 1972, drums have been inspected for free liquids, proper packaging, and use of the proper content code. Rejected drums are returned to the waste generator for correction. After inspection, 1 to 2 quarts of absorbent material (trade name Oil-Dri) were placed on top of the outer sealed polyethylene drum bag.

This procedure was changed in February 1982. Vermiculite is now used to fill the remaining space between the outer, sealed polyethylene drum bag

1970 - 1972: In most waste drums, approximately 10-20 lbs. of Oil-Dri was mixed in with the organic wastes and calcium silicate.



1972 - Present: Use of the 90-mil polythylene drum liner began. The inner plastic bag was replaced with an O-ring bag. Oil-Dri is usually mixed in with the waste.



INEL 2 1356

Figure 4. Solidified organic waste packaging methods.

and the top of the 90-mil rigid liner (see Figure 1). Depending on the amount of waste contained in the drum, the quantity of vermiculite added might range from 3 to 12 lb.

The rigid liner lid is then sealed on the rigid liner (if applicable). The 55-gallon drum lid and gasket are then installed and secured with a lock-chine.

Exceptions: Waste will periodically include bottles of organic wastes.

Waste Generator Contacts:

J. L. DiRocchi
P. T. Godésiabois
F. L. Lyons
M. E. Maas
R. A. Peterson

Record Information: INEL-TCWCIS

<u>Information (1971-81)</u>		<u>Drums</u>	<u>Boxes</u>
Total Containers		5621	0
Container Weight (lb) ^a	Maximum:	910	
	Minimum:	89	
	Average:	509	
Contact Dose Rate (mR/h)	<10:	5619	
	10-200:	2	
	Maximum:	35.0	
	Minimum:	0.0	
	Average:	0.4	

a. Approximate values.

<u>Information (1971-81)</u>		<u>Drums</u>	<u>Boxes</u>
Radionuclide Inventory			
Plutonium (g)	Maximum:	16.0	
	Minimum:	0.0	
	Average:	0.3	
Americium (g)	Maximum:	1.2	
	Minimum:	0.0	
	Average:	0.0	

Waste Form Evaluation:

Gas Generation--Organic content probably exceeds 14 lb/ft³. The gas generation potential for this waste form is not known. No known problems have been identified. Pressurized containers will be vented prior to shipping.

Combustibles--The waste contains more than 25 volume percent combustible material. Color coding will be required.

Immobilization--Absorbent materials mixed with the organic wastes form a grease- or paste-like material. Respirable or dispersible fines in excess of WIPP-WAC limits are not expected.

Sludges--The waste contains no identified sludges.

Free Liquid--Information concerning the potential for formation of free liquids is not complete. Characterization of a Content Code 3 drum, which was retrieved with other waste drums used in a 1980 study, revealed separation of the organic liquid waste from the calcium silicate. Approximately 2 gallons of organic liquid waste had formed inside the rigid liner, but outside the plastic bag containing the waste (the plastic bag had apparently split open). In addition, bottles of liquid wastes have periodically been included in the waste drums.

Explosives/Compressed Gases--No explosive, explosive mixtures, or compressed gases (49CFR173, Subparts C and G) have been identified in this waste.

Pyrophoric Materials--No pyrophoric materials (49CFR173, Subparts D and E) have been identified in this waste.

Toxic/Corrosive Materials--No corrosive materials (49CFR173, Subpart F) have been identified in this waste. Toxic materials such as beryllium and nitrobenzene are present in solidified organic wastes. Although specific information concerning all types and concentrations of toxic materials included in the wastes is not available, it is not anticipated that reportable quantities will be present. As a precautionary measure, all drums will be color coded.

Transuranic-contaminated oils containing polychlorinated biphenyls (PCBs) have periodically been processed with other organic wastes prior to 1980. Although PCBs are not presently defined as Poison A or Poison B materials based on the WIPP-WAC, the governing regulation for disposal of PCB waste is the Toxic Substances Control Act (see 40CFR761, Subpart B). Any item with a concentration of 500 ppm PCBs or greater is to be disposed of by incineration. The concentration of PCBs in oils processed with other Content Code 3 organic wastes is believed to be greater than 500 ppm. Records concerning processing of PCB contaminated oils are not complete. The following information concerning known or recorded processing of PCB oils is provided:

<u>Processing Date</u>	<u>Drum Number</u>	<u>Gross Weight (lb)</u>
5-25-76	743-13393	457
8-31-76	1-liter bottle of PCB oil buried in the middle of one of the following drums: 743-13465 to 743-13472	

<u>Processing Date</u>	<u>Drum Number</u>	<u>Gross Weight (lb)</u>
1-31-78	743-13948	624
	743-13949	524
	743-13950	615
	743-13951	644
	743-13952	615
	743-13953	641
	743-13954	639
	743-13955	537
2-14-78	743-13982	494
	743-13984	478

NOTE: 743-13983 should have residual PCB contamination.

The total number of PCB-contaminated Content Code 3 drums is unknown. The PCB contamination in a drum may be either localized or dispersed throughout the solidified organic waste matrix.

Certification Assessment: Solidified organic wastes shipped to the INEL prior to 1980 are not certifiable due to the presence of PCBs. Wastes received since then are certifiable, provided no free liquids are present. Color coding of drums for combustibles and toxic materials will be required.

3.6 Content Code 4

Content Description: Special Setups (prefix 744)

Generator: Rocky Flats Plant

Waste Description: Waste consists of liquids absorbed on a cement mixture. The liquid wastes are not compatible with aqueous treatment processes and are handled separately due to their plutonium complexing nature.

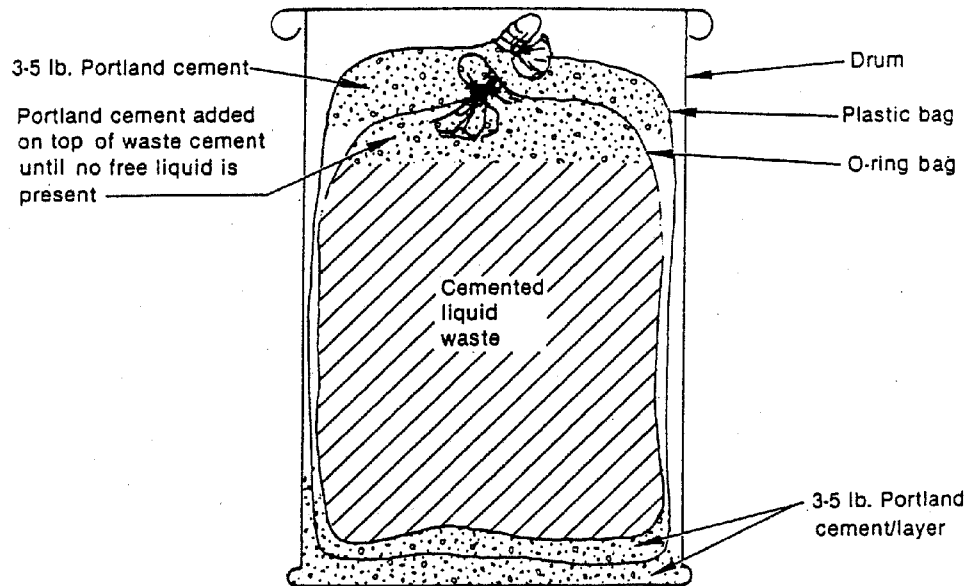
Generation Source: Majority of complexing chemical wastes are generated by various operations at Building 771 (Plutonium Recovery Operations). All wastes are processed by Aqueous Waste Treatment (Building 774).

Waste Form: Complexing chemicals include some alcohols, organic acids, and Versenes [trademark for a series of chelating agents based on ethylenediaminetetraacetic acid (EDTA)].

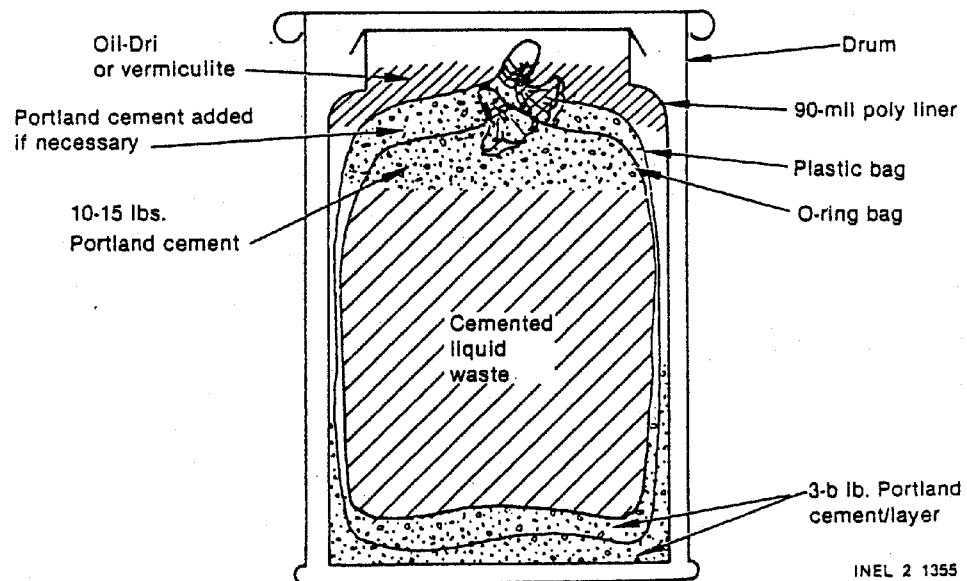
Recovery Method: All liquids are analyzed or assayed prior to release to Building 774 for treatment. Only below-discard contaminated wastes are released for processing. Above-discard contaminated wastes are processed by Plutonium Recovery Operations.

Waste Packaging and Handling: The cement mixture used for absorbing complexing liquid wastes is composed of approximately 190 lb of Portland cement and 50 lb of pipe insulation cement, such as magnesia cement. The cements are placed in a prepared 55-gallon drum; the drum is then placed on a drum roller and rolled to ensure mixing of the cements. All liquid wastes are made basic before adding them to the cement mixture. Approximately 100 liters (26.4 gallons) of liquid waste is then poured on the cement mixture and allowed to solidify. Approximately 10 to 15 lb of Portland cement is then added on top of the cemented liquid waste before the O-ring bag is removed from the glovebox. See Figure 5 for waste packaging methods.

1970-1972:



1972 - Present: Use of the 90-mil poly liner began in 1972.



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Figure 5. Special setups packaging methods.

Drum Preparation: See Figure 5.

Assay: Assay values for drums are either obtained by cumulating the assay information for each bottle emptied into a drum, or averaging the total quantity of fissile material contained in the liquid waste processed over the total number of drums of processed waste generated for each week.

Inspection: Since approximately 1972, drums have been inspected for free liquids, proper packaging, and use of the proper content code. Rejected drums are returned to the waste generator for correction. After inspection, 1 to 2 quarts of absorbent material (trade name Oil-Dri) was placed on top of the outer, sealed polyethylene drum bag.

This procedure was changed in February 1982. Vermiculite is now used to fill the remaining space between the outer, sealed polyethylene drum bag and the top of the 90-mil rigid liner (see Figure 5). Depending on the amount of waste contained in the drum, the quantity of vermiculite added may range from 3 to 12 lb.

The rigid liner lid is then sealed on the rigid liner. The 55-gallon drum lid and gasket are then installed and secured with a lock-chine.

Exceptions:

Some drums may be filled with the empty polyethylene bottles used to transport liquid waste to Building 774. A small amount of Portland cement is added to each bottle before placement in a drum (see Content Code 337).

Periodically, drums will contain polyethylene bottles of cemented liquid wastes. The bottles had been filled with the cement mixture and sent to various small waste generators for addition of the liquid waste. The bottles were then collected and placed in a prepared 55-gallon drum.

Waste Generator Contacts:

J. L. DiRocchi
F. L. Lyons
P. T. Godesiaboiss
M. E. Maas
R. A. Peterson

Record Information: INEL-TCWCIS

<u>Information (1971-81)</u>		<u>Drums</u>	<u>Boxes</u>
Total Containers		1237	0
Container Weight (lb)	Maximum:	1076	
	Minimum:	102	
	Average:	585	
Contact Dose Rate (mR/h)	<10:	1217	
	10-200:	20	
	Maximum:	180.0	
	Minimum:	0.0	
	Average:	1.2	
Radionuclide Inventory			
Plutonium (g)	Maximum:	22.7	
	Minimum:	0.0	
	Average:	1.0	
Americium (g)	Maximum:	2.4	
	Minimum:	0.0	
	Average:	0.0	

Waste Form Evaluation:

Gas Generation--Organic content and gas generation capabilities of this waste are unknown. Pressurized drums will be vented prior to shipping.

Combustibles--This waste form should contain less than 25 volume percent combustibles.

Immobilization--This waste should not contain respirable or dispersible fines. Dry Portland cement, which is added to the cemented liquid as an absorbent, is not considered particulate material.

Sludges--None identified in waste.

Free Liquid--No free liquids should exist in the waste.

Explosives/Compressed Gases--No explosives, explosive mixtures, or compressed gases (49CFR173, Subparts C and G) have been identified in this waste.

Pyrophoric Materials--No pyrophoric materials (49CFR173, Subparts D and E) have been identified in this waste.

Toxic/Corrosive Materials--No corrosive materials (49CFR173, Subpart F) have been identified in this waste. Reportable quantities of toxic materials may exist in the waste. Since specific information is not available for each drum, color coding will be required for all drums.

Certification Assessment: Waste is certifiable. Color coding all drums for toxic materials will be required since specific information is not available.

3.7 Content Code 5

Content Description: Evaporator Salts (prefix 745)

Generator: Rocky Flats Plant

Waste Description: Waste consists of a salt residue generated from concentrating and drying liquid waste from the solar evaporation ponds. The approximate chemical makeup of the salt is 60% sodium nitrate, 30% potassium nitrate, and 10% miscellaneous. Limited amounts of other wastes such as surgeons' gloves, paper, rags, and metal may be found in the waste drums.

The majority of salt drums in storage at the INEL should be contaminated with <10 nCi/g TRU. Salt waste is no longer shipped to the INEL.

Generation Source: Aqueous Waste Treatment (Building 774)

Recovery Method: None.

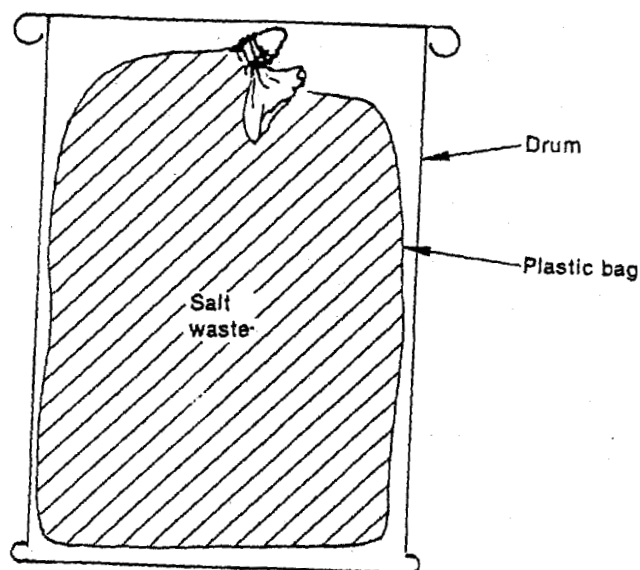
Waste Packaging and Handling: Liquid effluent from the second-stage treatment process and all other plant-generated liquid wastes not requiring treatment were concentrated in solar evaporation ponds. The liquid was then pumped from the ponds to the Building 774 evaporator, concentrated, and dried, forming a salt residue. The salt residue was packaged as shown in Figure 6. Portland cement was added to damp or wet salt when necessary.

Drum Preparation: See Figure 6.

Assay: Method unknown.

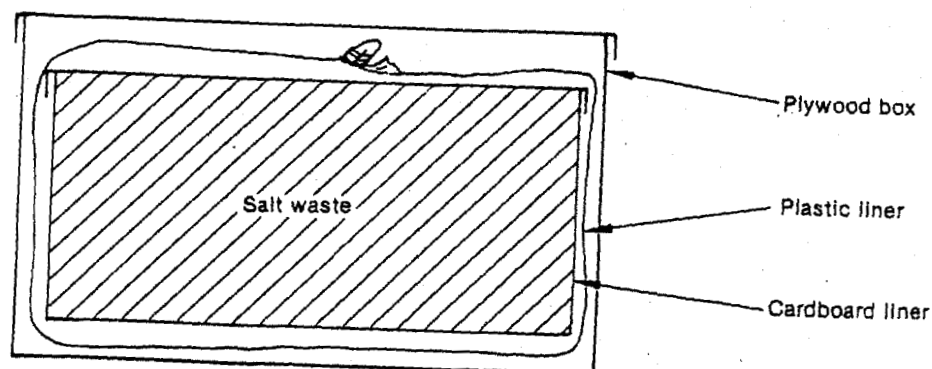
Inspection: Since approximately 1972, drums have been inspected for free liquids, proper packaging, and use of the proper content code. Rejected drums are returned to the waste generator for correction. After inspection, approximately 1 to 2 quarts of absorbent material (trade name Oil-Dri) was placed on top of the outer sealed polyethylene drum bag.

1970 - 1975:



Note: During 1972, approximately 1000 drums were lined with a plastic bag and a crepe paper bag. After this time, drums were lined with either one or two plastic bags.

1975 - 1978: In 1975, use of the 4x4x7 ft waste box began. After April 1978, salt wastes were shipped to the Nevada Test Site for disposal.



Note: On occasion, Portland cement was added to the salt mixture as moisture absorbent.

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Figure 6. Evaporator salt packaging methods.

The rigid liner lid was sealed on the rigid liner (if applicable). The 55-gallon drum lid and gasket were then installed and secured with a lock-chine.

Boxes were filled and sealed in the waste-generating area.

Waste Generator Contacts:

J. L. DiRocchi
F. L. Lyons
P. T. Godesiabois
M. E. Maas

Record Information: INEL-TCWCIS

Information (1971-81) ^a		Drums	Boxes
Total Containers		52	1 (1975 only)
Container Weight (lb)	Maximum:	465	4060
	Minimum:	314	4060
	Average:	364	4060
Contact Dose Rate (mR/h)	<10:	52	1
	10-200:		0
	Maximum:	1.0	1.0
	Minimum:	1.0	1.0
	Average:	1.0	1.0
Radionuclide Inventory			
Plutonium (g)	Maximum:		
	Minimum:		
	Average:	0.09	1.34
Americium (g)	Maximum:		
	Minimum:		
	Average:	0.10	1.57

a. Approximate information--based on waste generator information. Some drums marked as Content Code 5 drums are actually Content Code 1.

Waste Form Evaluation

Gas Generation--Organic content should not exceed 14 lb/ft³ for drums or 6 lb/ft³ for boxes.

Combustibility--Nitrate salts promote vigorous combustion of organic material. Drums containing paper, rags, gloves, etc. may constitute a combustible hazard. Color coding may be required.

Immobilization--The waste is in the form of salt flakes and may exceed WIPP-WAC limits. Any salt waste determined to be transuranic, based on assay results, will require processing, since information concerning salt particulate size is not available.

Sludges--None identified in this waste.

Free Liquids--The waste was dry or damp when packaged. An adsorbent (Portland cement) was added if any moisture was present. No free liquids should exist in this waste.

Explosives/Compressed Gases--No explosives, explosive mixtures, or compressed gases (49CFR173, Subparts C and G) have been identified in this waste.

Pyrophoric Materials--No pyrophoric materials (49CFR173, Subparts D and E) have been identified in this waste.

Toxic/Corrosive Materials--No reportable quantities of toxic materials have been identified in this waste. The salts may be corrosive if damp. Corrosion protection is provided by the plastic used for containment of the salt.

Certification Assessment: Transuranic salt waste will require processing since information concerning salt particulate size is not available. It is anticipated the majority of Content Code 5 waste will not be transuranic.

Appendix B

Chemical Compatibility Assessment for Operable Unit 7-10 Stage I and II Waste Generation Activities

Appendix B

Chemical Compatibility Assessment for Operable Unit 7-10 Stage I and II Waste Generation Activities

This appendix contains a copy of Appendix B from the *Chemical Compatibility Assessment for Operable Unit 7-10 Stage I and II Waste Generation Activities* (INEEL 2000), which documents the range of all potential binary combinations of chemicals determined to be in Operable Unit 7-10.

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Revision 0

**Chemical Compatibility Assessment
for Operable Unit 7-10
Stage I and II Waste Generation Activities**

Published March 2000

**Idaho National Engineering and Environmental Laboratory
Environmental Restoration Directorate
Idaho Falls, Idaho 83415**

**Prepared for the
U.S. Department of Energy
Assistant Secretary for Environmental Management
Under DOE Idaho Operations Office
Contract DE-AC07-99ID13727**

Appendix B
Chemical Compatibility Evaluation

Table B-2. Final compatability evaluation.

	Beryllium	Cadmium	Chromium	Lead	Mercury	Silver	Zirconium	Potassium nitrate	Sodium nitrate	Potassium dichromate	Sodium dichromate	Organic acids	Lithium oxide	Potassium chloride	Sodium chloride	Potassium sulfate	Sodium Sulfate	Potassium Phosphate	Sodium Phosphate	Versenes – EDTA	Carbon tetrachloride	Chloroform	Methylene chloride	Tetrachloroethylene	Freon 113	1,1,1-Trichloroethane	Trichloroethylene	Butyl alcohol	Alcohols	Methyl alcohol	Acetone	Xylene	Nitrobenzene	Sodium cyanide/ Cyanide	Graphite (broken molds)				
Beryllium	C																																				C		
Cadmium	C	C																																			Sodium cyanide/Cyanide		
Chromium	C	C	C																																		Nitrobenzene		
Lead	C	C	C	C																																	Xylene		
Mercury	C	C	C	C	C																																Acetone		
Silver	C	C	C	C	C	C																															Alcohols		
Zirconium	C	C	C	C	C	C	C																													Butyl alcohol			
Potassium nitrate	X	X	X	X	X	X	X	C																													Alcohols		
Sodium nitrate	X	X	X	X	X	X	X	C	C																											Butyl alcohol			
Potassium dichromate	X	X	X	X	X	X	X	C	C	C																										Alcohols			
Sodium dichromate	X	X	X	X	X	X	X	C	C	C	C																									Alcohols			
Organic acids	X	X	X	X	X	X	X	X	X	X	X	C																								Alcohols			
Lithium oxide	C	C	C	C	C	C	C	C	C	C	C	C	C																							Alcohols			
Potassium chloride	C	C	C	C	C	C	C	C	C	C	C	C	C	C																						Alcohols			
Sodium chloride	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C																					Alcohols			
Potassium sulfate	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C																				Alcohols			
Sodium sulfate	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C																			Alcohols			
Potassium phosphate	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C																		Alcohols			
Sodium phosphate	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C																	Alcohols			
Versenes – EDTA	C	C	C	C	C	C	C	X	X	X	X	X	X	C	C	C	C	C	C	C	C															Alcohols			
Carbon tetrachloride	C	C	C	C	C	C	C	X	X	X	X	X	X	C	C	C	C	C	C	C	C	C														Alcohols			
Chloroform	C	C	C	C	C	C	C	X	X	X	X	X	X	C	C	C	C	C	C	C	C	C	C													Alcohols			
Methylene chloride	C	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C													Alcohols			
Tetrachloroethylene	C	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C												Alcohols			
Freon 113	C	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C												Alcohols			
1,1,1-Trichloroethane	C	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C	C											Alcohols			
Trichloroethylene	C	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C	C	C										Alcohols			
Butyl alcohol	X	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C									Alcohols			
Alcohols	X	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C								Alcohols			
Methyl alcohol	X	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C							Alcohols			
Acetone	C	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C							Alcohols			
Xylene	C	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C						Alcohols			
Nitrobenzene	C	C	C	C	C	C	C	X	X	X	X	C	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C						Alcohols			
Sodium cyanide/ Cyanide	C	C	C	C	C	C	C	C	C	C	C	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C						Alcohols			
Graphite (broken molds)	C	C	C	C	C	C	C	X	X	X	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C						Alcohols			
C = Compatible																																							
X = Highly unlikely that chemical presents incompatibility concern based on estimated inventory and/or waste for m. Management “as if” incompatible is recommended as a best management practice pending final compatibility evaluation.																																							

X = Highly unlikely that chemical presents incompatibility concern based on estimated inventory and/or waste form. Management "as if" incompatible is recommended as a best management practice pending final compatibility evaluation.

